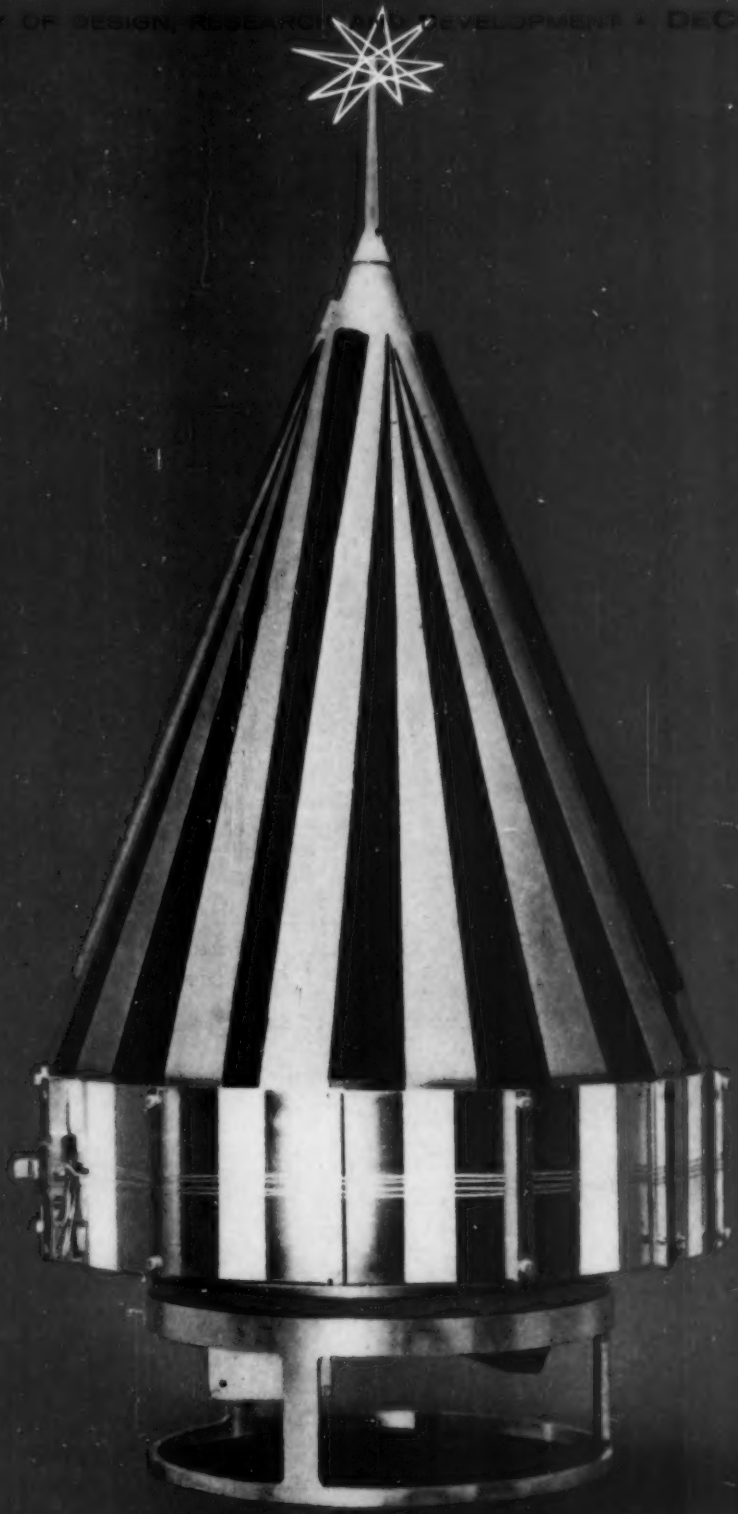
PRODUCT ENGINEERING

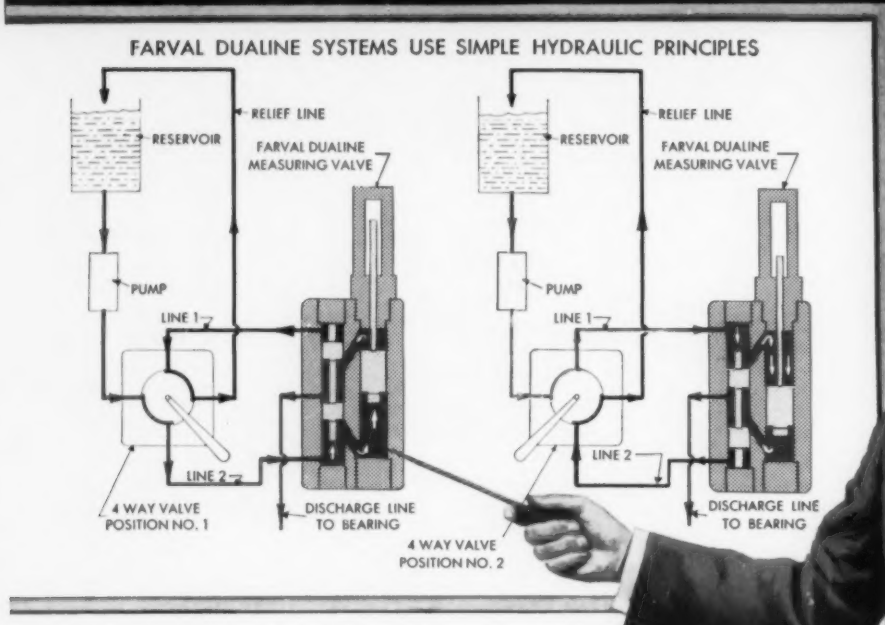
GRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT • DECEMBER 21, 1959

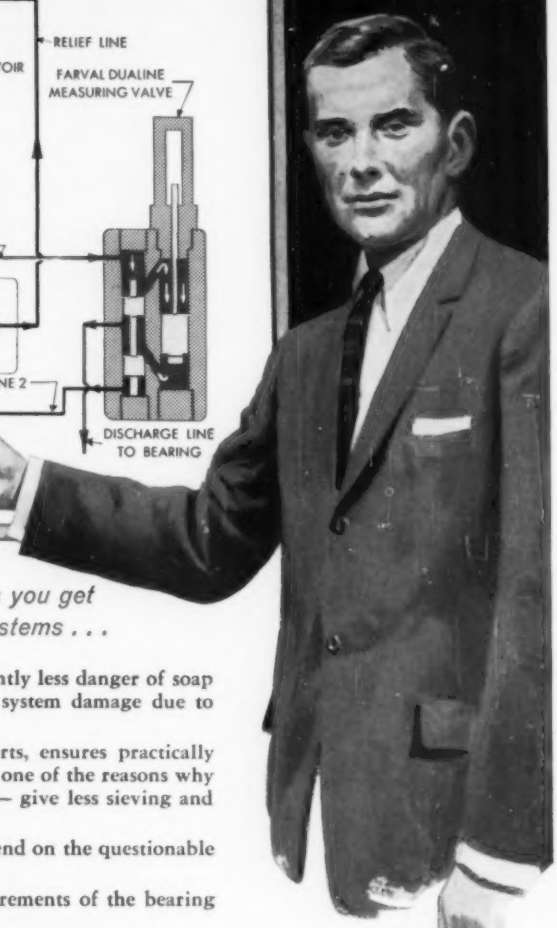


space research repeats a familiar Christmas shape... see page 5

FARVAL
—Studies in Centralized Lubrication
No. 246

"For positive lubrication of large, medium and heavy-duty installations . . . it's a Farval Dualine System!"





With Farval Dualine centralized lubricating systems you get the following distinct advantages over other type systems . . .

(a) Much lower operating pressures with consequently less danger of soap separation on grease systems. Also, less danger of system damage due to high lubricant pressures.

(b) Large lubricant passages with no pinhole ports, ensures practically full pump pressure for every metering valve. This is one of the reasons why Farval Dualine systems operate on lower pressures – give less sieving and working of lubricants.

(c) Positive indication at each bearing – does not have to depend on the questionable action of a single indicator at the pump.

(d) Each metering valve individually adjustable for the requirements of the bearing it serves.

(e) Independent metering valve operation. Should trouble develop with one valve, the system will continue to operate. Only one bearing (not all the bearings) will require hand lubrication until trouble is corrected.

(f) True lubricant metering. Quantity of lubricant delivered to one bearing is not dependent on any other valve in the system.

(g) Much easier to spot and correct trouble.

Check with your Farval Representative and see how these versatile systems can improve production operations – reduce costs. Or write for free Bulletin 26-T containing complete engineering information on Farval Dualine systems. The Farval Corporation, 3279 East 80th Street, Cleveland 4, Ohio.

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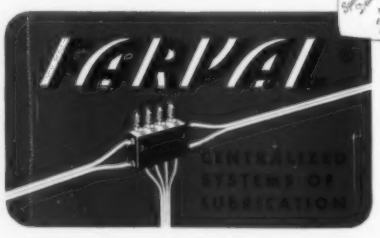


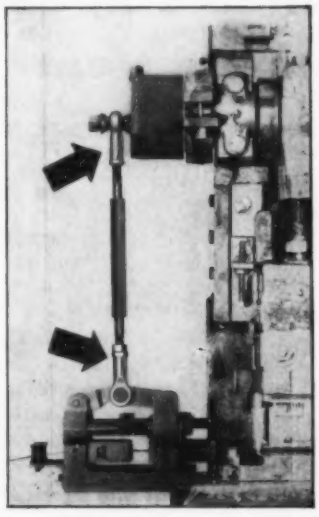
CIRCLE 201 ON READER SERVICE CARD

How to Make a Linkage

the easy way!

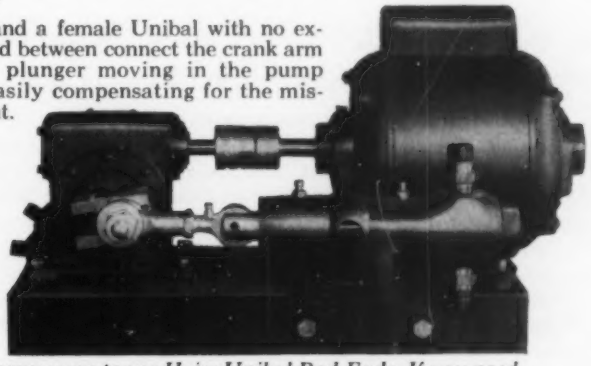
HEIM *Unibal*®
SPHERICAL BEARING
ROD ENDS

Quick and simple, yet highly effective linkage assemblies are possible with one female threaded and one male threaded Unibal rod end. There is practically no limit to the length of linkages possible.



The misaligned distance between centers is quickly and infinitely adjustable using right and left hand threaded Unibals and an appropriately threaded shaft, using jam nuts to secure the adjustment.

A male and a female Unibal with no extender rod between connect the crank arm and the plunger moving in the pump frame, easily compensating for the misalignment.



There are many ways to use Heim Unibal Rod Ends. If you need engineering or design help, it is available through our engineering department.

Write for list of distributors and the complete catalog . . .

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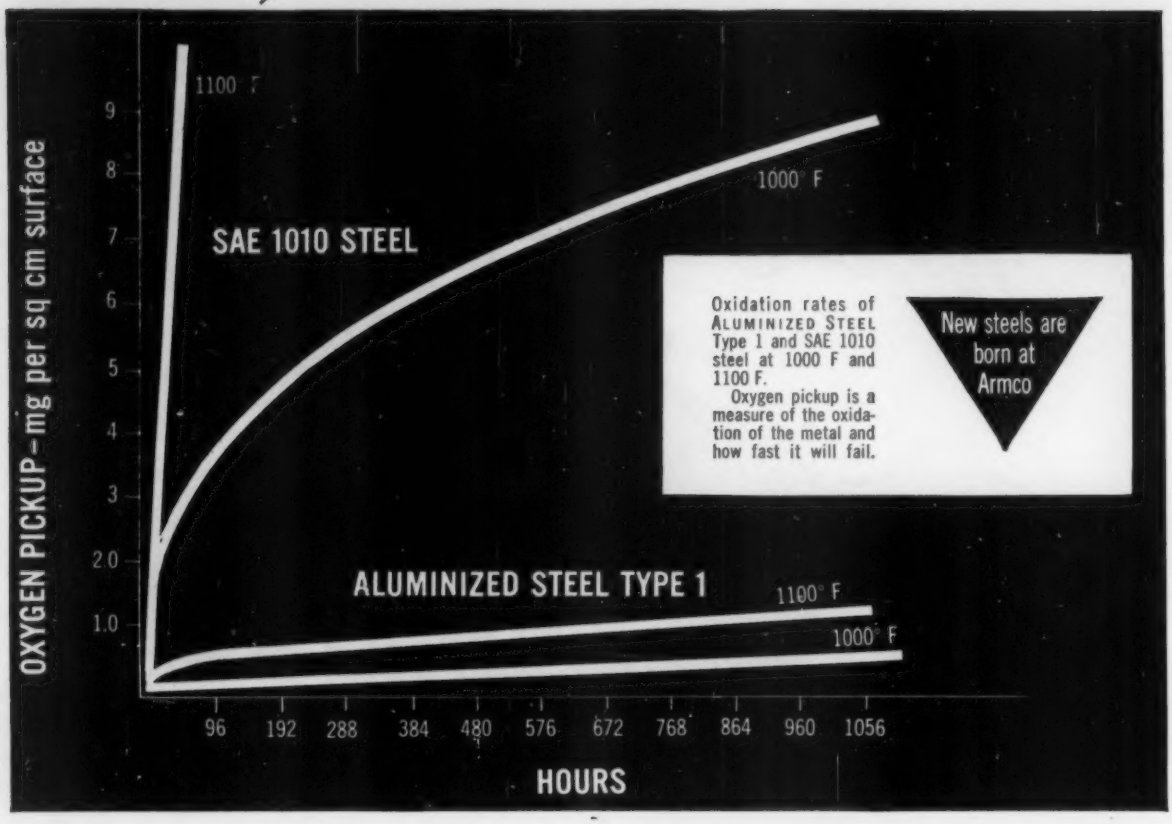

Research Data Shows Why Armco's Special Aluminum-Coated Steel Withstands Heat

Comparative oxidation rates indicate remarkable durability of corrosion-resistant Armco ALUMINIZED STEEL Type 1 at high temperatures.

Oxidation rates of ALUMINIZED STEEL Type 1 at 1000 and 1100 F compared with those of SAE 1010 steel demonstrate why this special Armco Steel has become a popular material for parts that must resist heat.

The hot-dip aluminum coating applied by a special Armco-developed process prevents oxygen from destructively scaling the base metal at temperatures up to about 1250 F. In addition, ALUMINIZED STEEL also provides good corrosion resistance. This unique combination of steel and aluminum withstands the corrosive attack of combustion products and condensates.

Because ALUMINIZED STEEL Type 1 combats both heat and corrosion and because its steel base gives parts high strength, it can be used in thinner gages and at higher temperatures than other metals.

For these reasons, Armco's special aluminum-coated steel has proved to be the most economical and durable metal for auto mufflers, heat exchangers, combustion chambers, industrial ovens, appliances, and similar products requiring resistance to heat and corrosion. Put the cost-cutting, performance-improving advantages of Armco ALUMINIZED STEEL Type 1 to work in your products. Write us for complete information. Armco Steel Corporation, 3249 Curtis Street, Middletown, Ohio.

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DESIGN issue

Product Engineering

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

December 21, 1959 Vol. 30, No. 52

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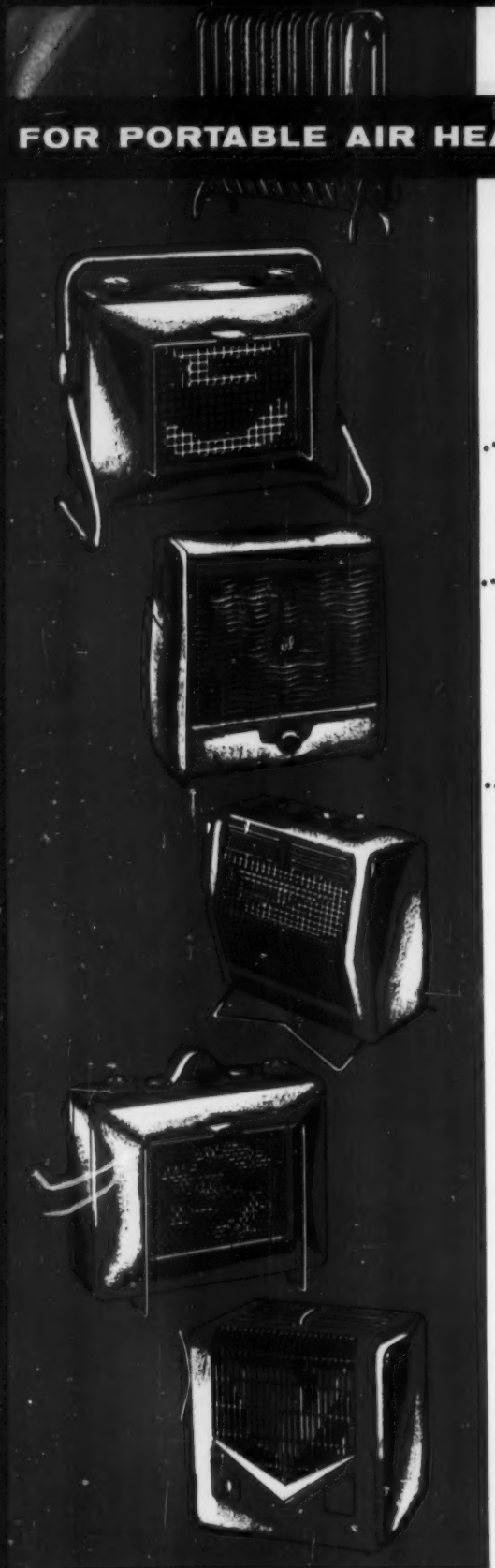
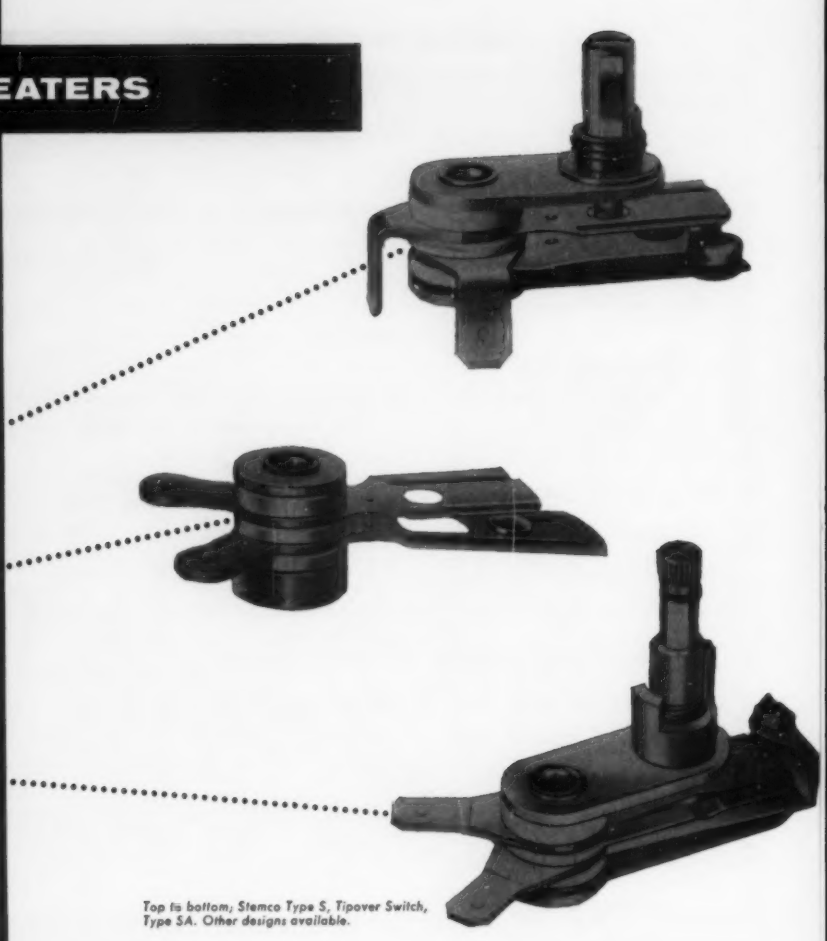
FOR PORTABLE AIR HEATERS





Top to bottom; Stemco Type S, Tipover Switch, Type SA. Other designs available.

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No wonder leading manufacturers of portable air heaters specify Stemco thermostats. For Stemco thermostats give long-life reliability that eliminates service headaches . . . are quickly, easily installed . . . are competitively priced. Our application engineering service is eager to help you solve your thermostatic control problem, whether it involves design, production or cost. Try us *now.* AA-9041

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Interesting to Note . . .

The First Christmas Card

An eccentric 19th-century Englishman who died in 1912 at the age of 85 is largely responsible for an increasing amount of knowledge on the origin of our modern Christmas tradition. The man was Jonathan King, a passionately dedicated collector who devoted 60 years of his life to amassing, in his London home, more than a half million Christmas cards published since 1843.

That was the year the Christmas tree was introduced in England. In the same year the first Xmas card was designed by John Calcott Harsley, a widely known artist of the period. (Pictured below, this first card now is part of the Hallmark Historical Collection.)

Early Christmas cards were usually drawn by noted artists. In England, the name of Kate Greenaway, whose paintings of children became world-famous, was closely associated with Christmas cards. In America, Louis Prang, the Boston lithographer, published the best early Christmas greetings between 1870 and 1900. Strangely, the Currier and Ives illustrations, so popular on cards today, were not reproduced as Christmas greetings until the 20th century.

At the turn of the century, Christmas cards temporarily went out of fashion with the influx of German postcards. It wasn't until 1910 that Christmas card manufacturers began to achieve success.

Symbols of Christmas – the robin, Santa Claus, holly, mistletoe and carolers – first became popular on cards around 1850. Now the Space Age has given us added symbols–rocket ships, celestial bodies, satellites. On our cover this week, for example, the design is not that of a modern Christmas tree but of a nosecone.

This is because, with the current emphasis on space research, we thought you'd like to see a real closeup of the nose of Pioneer IV, launched last March 3 to study radiation in space. It carried a 12-lb payload past the moon into orbit around the sun, where it will apparently be from now on. Jet Propulsion Labora-

CONTINUED ON PAGE 7

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IRREGULAR SHAPES IN GEARS AND OTHER PARTS

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Irregular shapes can be production machined accurately and quickly on the Fellows Gear Shaper. The Fellows principle of gear generating with a reciprocating cutter makes it a simple job to generate square or elliptical shapes, cams, pawls, pump rotors, and many other contours, both internal and external.

With the proper cutter and, depending on the part design, a fixture in which the work is located off-center or one which varies the center distance relationship of cutter and work as the cutting progresses, quantity production of parts such as those shown here is as fast and simple as cutting spur gears.

Using special cutters and fixtures designed by Fellows, the Gear Shaper can produce a remarkably wide variety of contours at high production rates. For example, one section of the cutter shown below finish cuts one side of this very odd shaped pawl. Cutting is almost continuous with a magazine type fixture having eight loading stations. For further information on generating irregular shapes on the Fellows Gear Shaper get in touch with any Fellows office.

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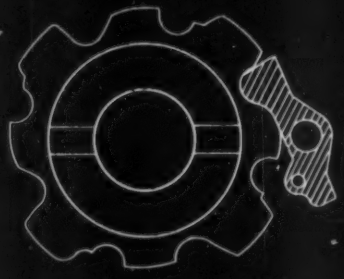
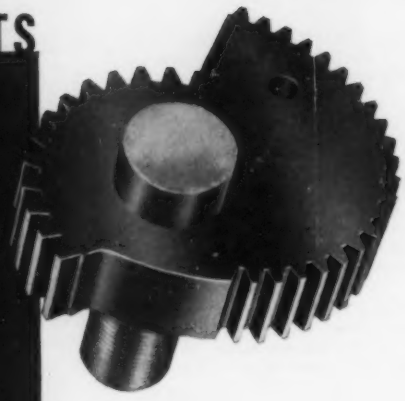
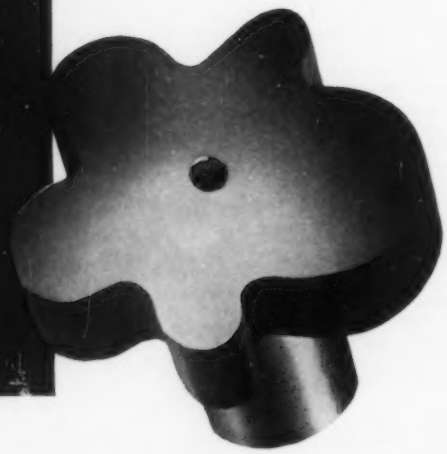






THE PRECISION LINE

Fellows *Gear Production Equipment*

tory, Pasadena, Calif, produced the nosecone and assembled its payload. The prominent black stripes were put on the exterior to control interior temperature by balancing the amount of radiant heat accepted from the sun against the amount radiated to space from the dark side of the payload. Original firing time and trajectory called for white stripes (see assembly photo here), but firing time was delayed for several nights. This meant a change in trajectory, so relationship between sun and payload was changed as well—and the striping accordingly had to be changed from white to black. We added the star suggestion at the top, and trust you will accept it as our wish for a merry—and spacious—Christmas.

The Hoaxters

Now that the quiz show frauds have been exposed people have asked, "How could so many people have been taken in by such a hoax?" Well, if this is any consolation, the public periodically becomes the victim of some such fraud. Not too long ago, it was discovered that the Piltdown Man, previously thought to be another important chain in man's ancestry, was "fixed." However, we've got to go back to 1835 for one of the greatest hoaxes perpetrated upon the public. In that year a New York newspaper, *The Sun*, devised a scheme to boost its circulation. On the 2nd page of its Aug 25 issue, the paper said that a British astronomer, stationed at the Cape of Good Hope, was about to test a new telescopic principle. The following day the paper, quoting a defunct Scottish science journal, described animals on the moon "having all the characteristics of . . . bison."

Circulation rapidly increased as *The Sun's* stories of moon-beings became more fantastic. Next observed on the moon were men who "averaged four ft in height; were covered, except on the face, with short and glossy copper-colored hair; and had wings composed of thin membranes without hair . . ." At this, circulation jumped so fast, that presses had to run 10 hours a day to supply the demand. Gulled New Yorkers crowded outside *The Sun's* offices to wait for latest editions. The paper's rivals pirated the stories, claiming to have obtained them independently from an original source.

The situation was getting out of hand. So, on Aug 31, *The Sun* printed its last lunar dispatch. The public was told that the astronomer's telescope had been left facing east. Unfortunately, the rays of the sun coming through the lens burned a hole "15 feet in circumference" all the way through the reflecting chamber. Only many years later was the hoax made public by *The Sun's* publisher. The paper never lost the circulation it obtained with the moon-fraud.

Several decades later came another notable attempt to cash in on the public's interest in science. Farmer William Newell hired several men to dig a well on his property in Cardiff, NY. At a depth of about five ft, the well-diggers struck a solid object. Since they couldn't dig around it they had to remove it, and the figure of a petrified man, 12 ft tall and 4 ft thick was unearthed. Word quickly spread that a giant had been discovered. Local doctors helped by claiming it to be a true petrified man. A Yale Divinity School graduate identified it as an idol with folded wings.

Only after this "Cardiff Giant" received nationwide publicity and people flocked to see it, was the nature of the hoax revealed. George Hull, Binghamton, NY, had hired a stonecutter to make the huge model of a giant. Models have saved many a dollar for engineers (p 60)

Courtesy, N. Y. State Historical Assoc., Cooperstown, N. Y.

but Hull's model of a giant was "planted" to make money; and make money it did. Hull claimed he buried the huge granite statute to needle an evangelist who believed giants lived during Biblical times.

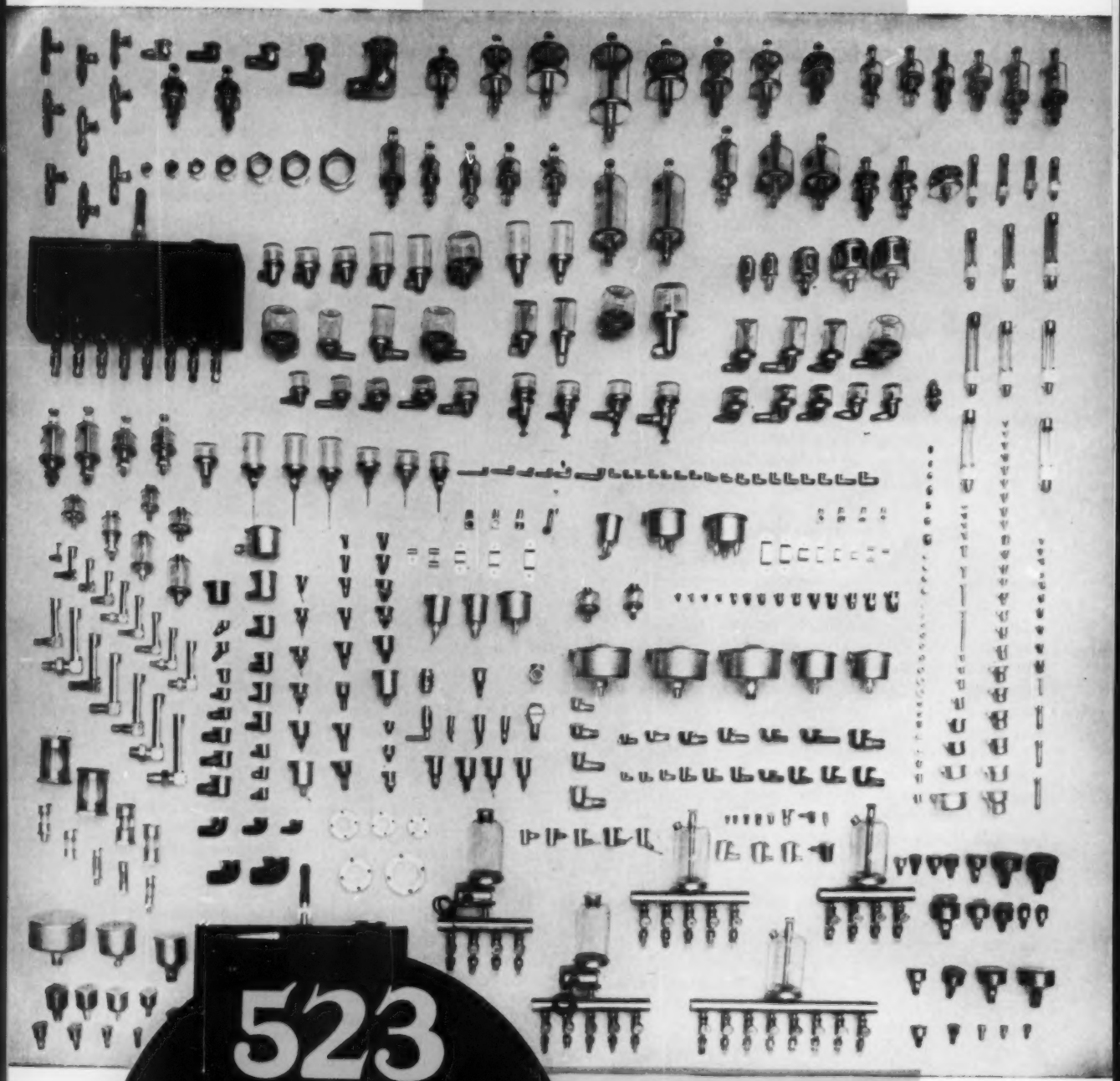
Even after the hoax was discovered, Hull went on exhibiting his "creature" for profit. P. T. Barnum, the great showman, offered to buy the Cardiff Giant. When Hull refused to sell it, Barnum hired a stonecutter, had a copy made, and exhibited it as the genuine article.

Those Airway Traffic Jams

Fighting the traffic maze in any major city during rush hours is the price we pay for progress. However, rush-hour traffic isn't limited to cars. The overcrowded conditions above us are getting increasingly worse. Where cars become clogged for 10 or 15 miles, planes are backed up 200 to 500 miles. Bad weather makes conditions worse. Says James T. Pyle, head of the Federal Aeronautics Agency, "When we limit (air) traffic into New York, it backs up westward to Chicago and Kansas City and southward to Atlanta and even Miami."

The problems of today's air traffic controllers are gigantic. In 1946 there were 104,000 instrument approaches; by 1970 the number will exceed 3 million. Where there were 4 million takeoffs and landings in '46 there will be 30 million in '65. No wonder we have airplanes crinkling their "fenders" in mid-air. Recently a system called "Iconoramic" was developed by Fenske, Fedrick and Miller Inc. This system described on page 50, makes it possible to use automatic equipment for plotting the paths of aircraft—thus eliminating the problems of system saturation. On April 27, 1958, Jack Fedrick, one of the members of this engineering firm, was flying to Colorado Springs with a plan he wanted to sell to the Air Defense Command. His proposal was the use of this "Iconoramic" system to prevent mid-air collision. Over Las Vegas his plant collided with an Air Force jet and he was killed. A rather ironic way to make a point.

—Benedict A Leerburger Jr



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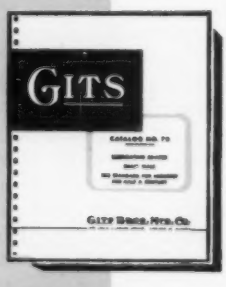

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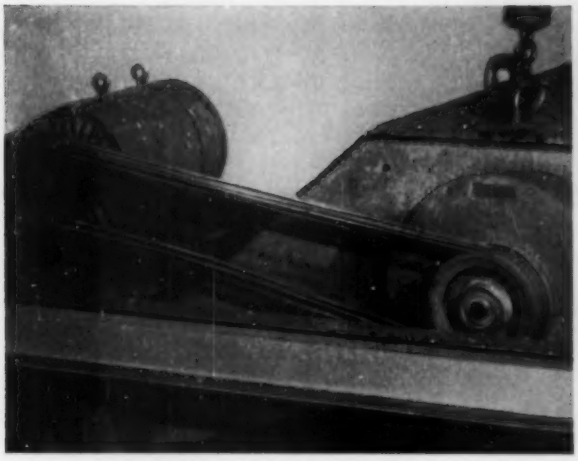
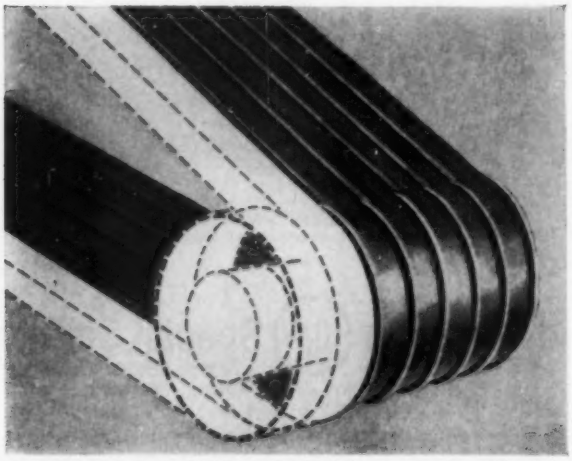


1. EXTRA-LONG SERVICE LIFE. V-belts made with "Dacron" kept this car shakeout on the job three full years without a belt change—52 times longer than with previously used conventional belts! Evidence of the remarkable ability of these belts to withstand shock loads and constant flexing.

2. REDUCE EXPENSIVE INVENTORIES. V-belts reinforced with "Dacron" have outstanding dimensional stability. They won't shrink or stretch in storage . . . assure quick, positive matching for fast installation . . . eliminate costly downtime for adjustments.



3. 5 BELTS DO THE WORK OF 7. The extra strength of V-belts reinforced with "Dacron" allows the use of fewer belts and sheaves . . . permits up to 40% more horsepower per drive unit, without an increase in the number or size of sheaves.

Savings of as much as 10% per drive unit are possible when you use V-belts reinforced with Du Pont "Dacron"* polyester fiber. The strength, stability and extra life of these belts combine to bring down drive costs . . . through less downtime and smaller inventories . . . fewer belts and sheaves . . . lower maintenance and fewer replacements.

For the next drive you design or install, be sure you specify V-belts reinforced with Du Pont "Dacron". Du Pont makes the "Dacron" fiber used by belt manufacturers in producing their finest-quality V-belts.

SEND FOR FREE BOOKLET: "Du Pont 'Dacron' Sets New Standards for V-Belt Performance". For your copy, fill out and mail coupon below.

*"Dacron" is Du Pont's registered trademark for its polyester fiber.

E. I. du Pont de Nemours & Co. (Inc.)
Textile Fibers Department
5518-(C) Nemours Bldg.
Wilmington 98, Delaware

Name _____ Title _____

Firm _____

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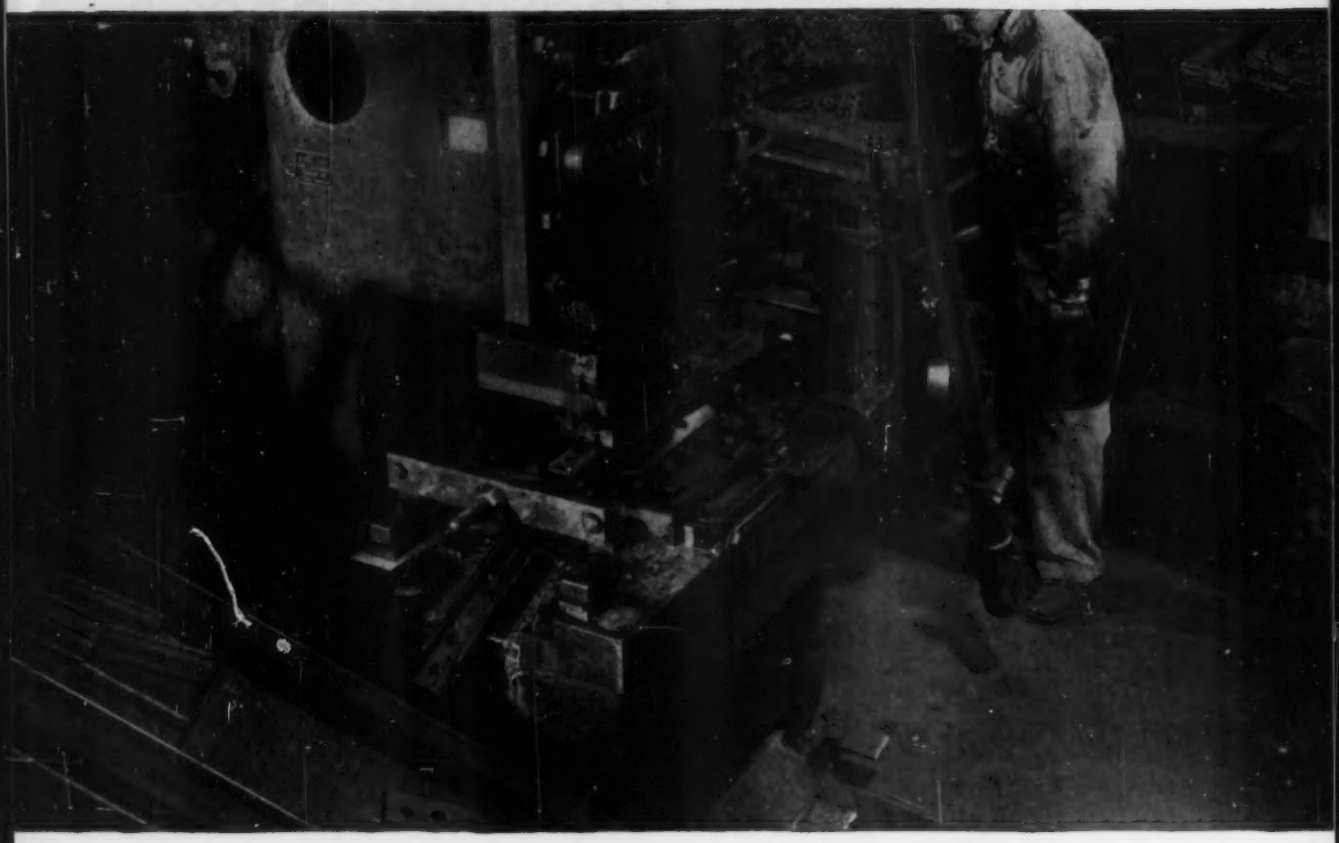
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

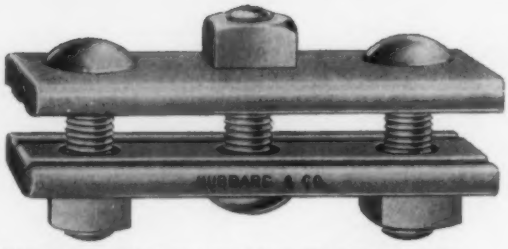
←CIRCLE 8 ON READER SERVICE CARD

CIRCLE 9 ON READER SERVICE CARD

STEEL SHAPED TO CUT COSTS AND IMPROVE PRODUCTS



One automatic operation punches three holes and shears off the part from a USS Hot-Rolled Special Section. No machining necessary.



Hubbard pole line hardware made from USS Special Sections.

Pole line hardware • one punch • made from USS Special Sections

Hubbard and Company is one of the largest pole line hardware manufacturers in this country. They turn out guy clamps, cable suspension clamps and lashing clamps by the thousands. To keep production costs low, they use USS Special Sections already rolled to the proper cross section for the finished piece.

Many items can be punched and sheared in one automatic operation so that there is no machining and very little scrap. Parts can then be galvanized, bolts inserted and the job completed.

How USS Special Sections can reduce your costs. If you have an irregular steel part that must be produced in quantity at low cost, let us check your drawings. Many times a complex and costly assembly can be replaced by the use of one USS Hot-Rolled Special Section. Designs are unlimited. Write for our new book showing many intricate shapes already being produced. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is a registered trademark

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company

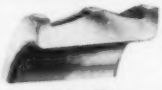
United States Steel

The best features of modern bearing design — combined and refined in

Spherical

ROLLER BEARING PILLOW BLOCKS BY LINK-BELT

MAXIMUM SIZE ROLLERS



HIGH, HEAVY INNER RACE FLANGES

CENTRIFUGALLY CAST BRONZE RETAINERS

Big, mirror-smooth, convex rollers . . . hefty inner race flanges . . . centrifugally cast bronze, precision-machined retainers. They're industry's *preferred* bearing features. And they're *all* found in Link-Belt's new spherical roller bearing . . . compactly combined in an exceptionally durable two-piece housing.

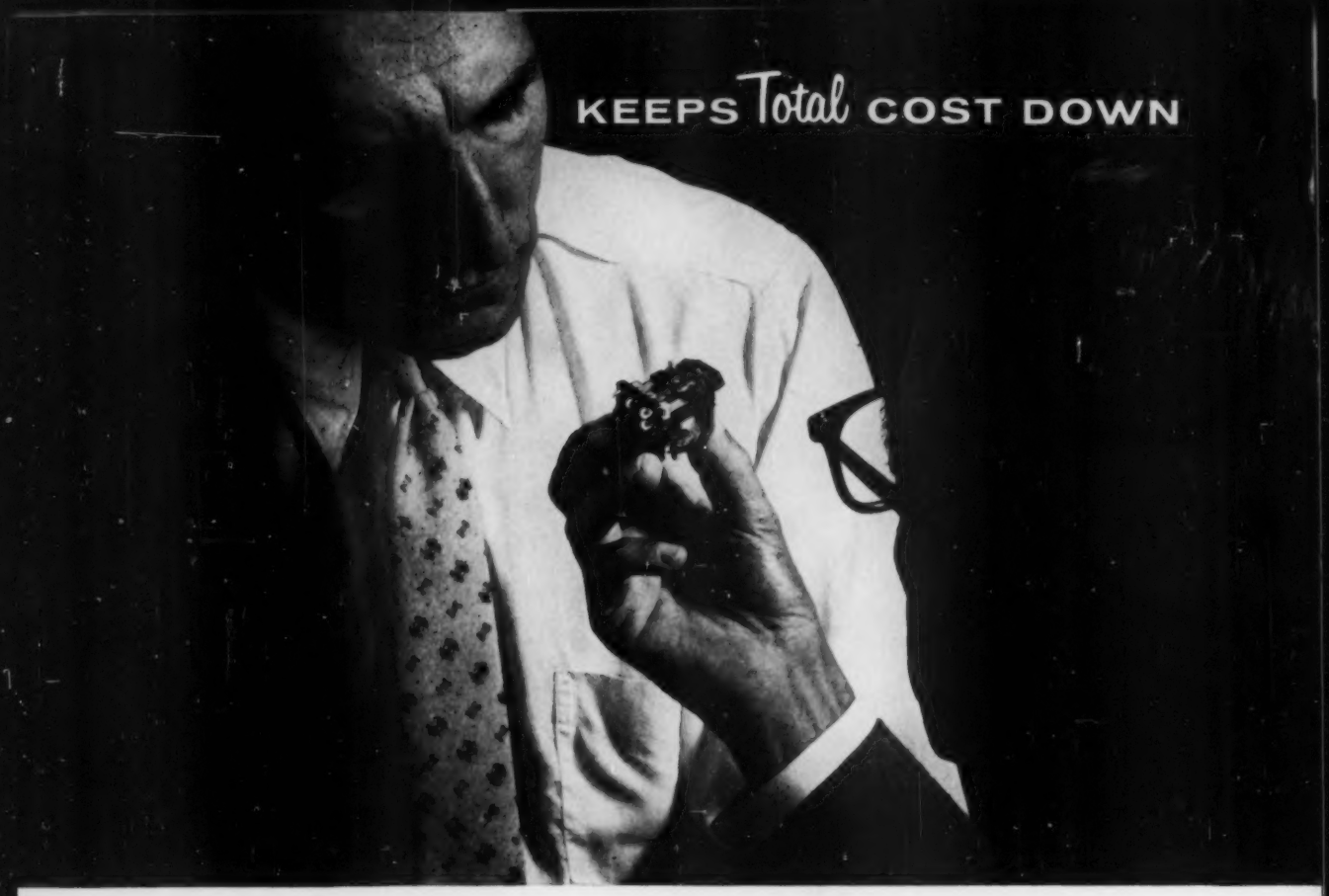
These self-aligning roller bearing pillow blocks take misalignment in stride—adjust immediately in any direction while maintaining full load capacity. Two types of shaft mountings facilitate installation . . . adapter mounting for commercial shafting and direct shaft mounting for shafting ground to recommended tolerances. And Link-Belt's rugged steel multi-labyrinth or dacron-contact seals lock out dirt, lock in lubricant.

For details, call your Link-Belt office and ask for new 52-page Book 2760. Look under BEARINGS in the yellow pages of your phone book.

Series 6800, 6900, 7800, 7900 roller bearing pillow blocks have spherical roller bearings with internationally standardized boundary dimensions.

SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,161-A



IF INSTALLED-COST IS A DESIGN PROBLEM

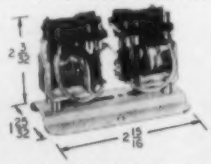
Look at the KA general purpose RELAY

What do your relays cost *installed?* Initial cost is never the whole story.

Our KA Relays are engineered for modern production methods. They're available with printed circuit, taper tab, quick-disconnect or hook solder terminals . . . are simple, economical to install. This fact, combined with low original cost, keeps your total cost down.

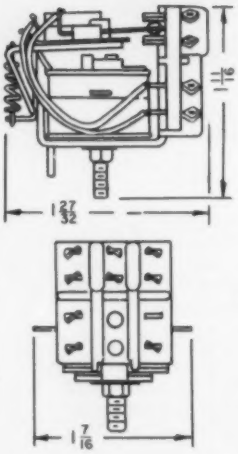
Another source for savings! All standard KA ac relays bear U/L and Canadian Standard Association seals of approval.

Write or call for more information or see the complete P&B catalog in Sweet's Product Design File.



KB LATCHING RELAY consists of two KA Relays, forming a mechanical latching relay, featuring a large number of contact arrangements.

KA ENGINEERING DATA



GENERAL:

Insulation Resistance: 100 megohms min.
Breakdown Voltage: 1500 V. rms between all elements.
Temperature Range:
−55° C. to +85° C. DC
−55° C. to +70° C. AC
Weight: 2.0 ozs.
Pull-In: DC 75% of nominal voltage.
AC 78% of nominal voltage.
Terminals: Taper tabs.
Printed circuit.
Quick-disconnect.
Pierced solder lugs.
Enclosures: Dust Cover
(max. 55° C. ambient for AC relays)
(max. 70° C. ambient for DC relays)

CONTACTS:

Arrangements: 3 Form C (3PDT) max.
Material: Movable—⅛" silver; stationary—$\frac{5}{32}$" wide silver overlay.
Load: 5 amps @ 115 V. AC 60 cps res.

COILS:

Resistance: 16,500 ohms max.
Power: 1.2 watts (DC), 2 volt amps (AC)
Duty: Continuous AC or DC (DC coils will stand 4.5 watts at 25° C.)

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA
IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

CIRCLE 12 ON READER SERVICE CARD

QUICK COMPARISON CHART

Some unique combinations of electrical and physical properties in Anaconda metals that may save you money—handle tough jobs better

Properties shown for precipitation-hardened condition—Heat-treatable alloys	ELECTRICAL CONDUCTIVITY % IACS	TENSILE STRENGTH psi	YIELD STRENGTH at 50% ext. under load, psi	ELONGATION % in 2 in. or 4xD	MACHINABILITY compared with F.C. Brass at 100	FORMS AVAILABLE
Chromium Copper-999 (Cu 99.05%, Cr .85%, Si .10%)	75	65,000	55,000	20	20	Rod Wire Tube Forgings Strip
Leaded Nickel Copper-831 (Cu 97.8%, Pb 1.0%, Ni 1.0%, P .2%)	55	80,000	70,000	7	80	Rod
Cunisil-837 (Cu 97.5%, Ni 1.9% Si .6%)	30 to 42	90,000	70,000	8	40	Rod

To give you a basis of comparison, here are properties of two standard Anaconda electrical coppers

ETP Copper—100 (Cu 99.9+%)	100	48,000	40,000	15	20	All mill forms
Leaded Copper—126 (Cu 99.0%, Pb 1.0%)	98	48,000	40,000	12	80	Rod bar

The values given above are intended as a guide to some unusual combinations of electrical and physical properties available among Anaconda alloys. If any of them gives you an idea for possible solution to a tough problem or indicates a way to cut costs without sacrificing quality or performance — see your American Brass representative for more details. Or send in this coupon today.

6940

COPPER • BRASS • BRONZE • NICKEL
SILVER MILL PRODUCTS

ANACONDA®
PRODUCTS

Made by The American Brass Company

The American Brass Co., Waterbury 20, Conn.
In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

Please send me more information about the following alloys:

☐ Chromium Copper—999 ☐ Leaded Nickel Copper—831
☐ Cunisil—837 ☐ Leaded Coppers
☐ Electrolytic Tough Pitch Copper—100

Name .....
Company .....
Street .....
City ..... Zone ..... State .....

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

The choice between a cap screw and socket head screw

If you have the choice, make it a socket screw when you have a space problem, but choose the cap screw for more holding power per dollar.

No question that you should apply socket screws in counterbored holes; and that you can clear tight spaces. What you can't do is utilize the full strength of the alloy needed for the socket head. And remember, strength of a connection depends on how you preload the fasteners, and not on the strength of the fastener material alone.

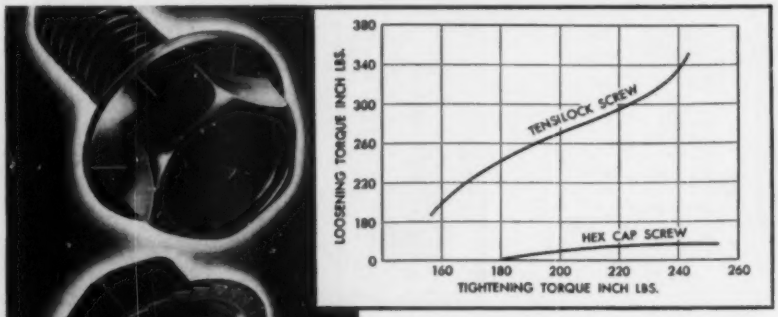
THE HANDICAPS OF ONE

Internal wrenching rarely develops as much torque as needed for proper preloading. And if high torque is developed, the smaller bearing area of the socket head tends to crush the surface on which it bears rather than increase tension or preload.

THE ADVANTAGES OF THE OTHER

If you design to take advantage of heat treated cap screws of SAE grade 5 quality, you'll get a stronger connection at lower cost. These standard fasteners have ample bearing and wrenching surfaces, can be torqued right up to yield strength. They also cost less than the alloy fasteners.

New TENSILOCK* Screws seat tighter, lock tighter



Graph shows example of on-torque and off-torque relationship. It takes more torque to loosen than to tighten.

RB&W's new TENSILOCK screws, the toothed fasteners with high tensile locking, are identified by six radial dashes on flange.

Head has integral washer face with teeth that lock fastener to surface. Circular groove allows flange to flex and seat to bear solidly on surface.

RB&W's TENSILOCK fasteners feature ratchet-like teeth formed at an angle which cuts driving effort yet which enables the teeth to bite in firmly and give an improved grip against back-off.

In addition, a circular groove in the integral "washer" permits the flange to flex upon tightening, and helps maintain tension in the fastener and pressure on the teeth.

IMPROVED TENSION TO TORQUE RATIO

With reduced friction under the head, the new tooth design has enabled more of the wrenching torque to be used to develop tension and less to overcome friction. Since the flange flexes, it allows the screw to bear solidly on its seat. All of the high strength capabilities of these heat-treated one-piece fasteners can now be attained for a stronger assembly.

MORE LOCKING POWER

Tensilock screws need up to 40% more off-torque than on-torque. Combining this feature with the higher residual tension, and the diaphragm action of the integral washer face, these fasteners give superior locking and holding power for permanently tight, strong joints . . . even under severe vibration and cyclic temperature changes.

Now available in limited range of screw types (not in flat head), and in various nut sizes. For details, write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

*Trade Mark Pat. applied for.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

"WEIRKOTE® WON'T PEEL OR FLAKE—AND CAN END THE NEED FOR FURTHER CORROSION PROTECTION AFTER FABRICATION."

Q. A zinc-coated steel sheet that won't peel or flake, even under the severest fabricating stresses?

A. Precisely. Weirkote's made by a continuous process. The zinc is so integrated with the steel that even the toughest "torture" tests of fabrication leave that bonded coating intact. You can work Weirkote to the very limits of the steel itself!

Q. Our products are pretty intricate—take lots of flexing, crimping and so on. What about those hard-to-reach places?

A. Weirkote's zinc coating is so uniform—protects even the most complicated parts.

Q. So with Weirkote you bypass the need for further corrosion protection?

A. You get the picture! Think of the time, labor, space—the costly capital outlay—you save. Better steel products at far lower costs—that's Weirkote for you!

Send for free booklet that details the time-and-cost-saving advantages of skin-tight zinc-coated Weirkote. Just write Weirton Steel Company, Dept. D-2, Weirton, West Virginia.

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

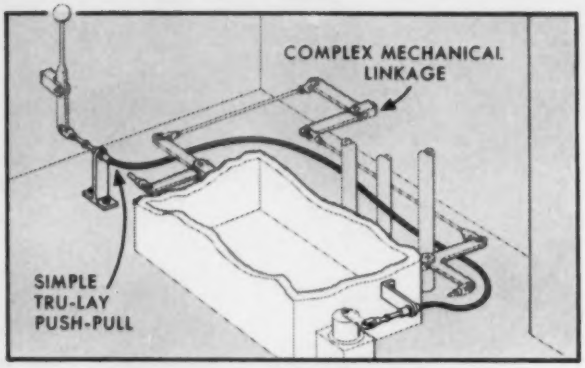
a division of

NATIONAL STEEL CORPORATION

CIRCLE 15 ON READER SERVICE CARD

TRU-LAY *PUSH-PULL* CONTROLS PROVIDE ACCURATE, DEPENDABLE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000

Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

Selective Friction • Amount of friction can be changed to meet individual requirements of the operator or application. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Available in two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment. Built for smooth, efficient operation on any job.

PUSH-PULL DATA FILE shows how to simplify, improve design

PUSH-PULL CONTROLS are solid as a rod and flexible as a wire rope. They're factory-lubricated for life, unaffected by temperature extremes, and can be adapted to practically any application. For complete details on how you can use them, write for the PUSH-PULL DATA FILE. It contains 7 engineering Bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages. Our engineers will be glad to help you make TRU-LAY PUSH-PULL CONTROLS a part of your product.

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

601-E Stephenson Bldg., Detroit 2

6800-E East Acco St., Los Angeles 22 • 929-E Connecticut Ave., Bridgeport 2, Conn.

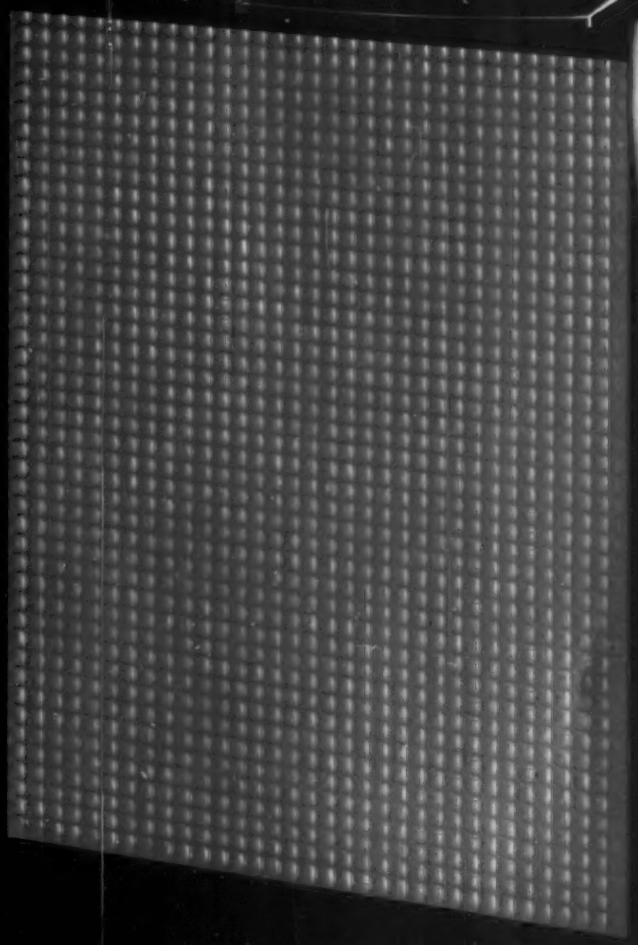
ACCO

CIRCLE 17 ON READER SERVICE CARD→

Just a touch tells you—

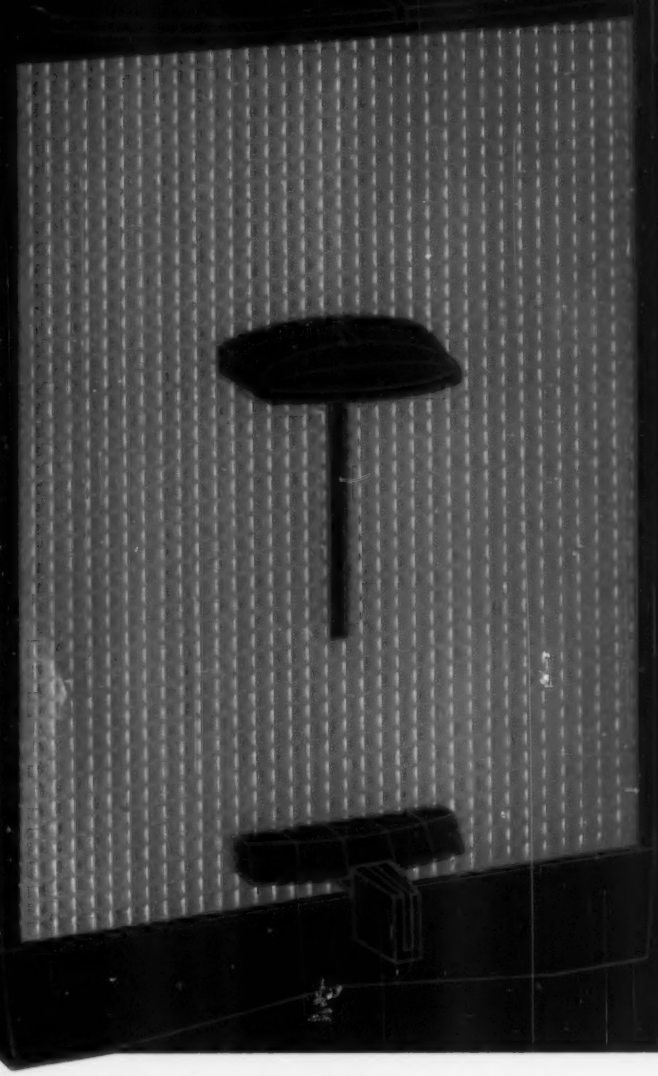
how this
Mary Proctor
Toaster
took on new

sales appeal



Gold-finished panels of USS American Embossed Amerstrip add richness, smart modernity to classic toaster lines

New Proctor Electric Company toaster styled by Raymond Loewy Associates has special design USS Embossed Amerstrip



This Mary Proctor toaster is beautiful—and different. On the sales counter it stands out from its competitors. Much of this sales-pulling distinction lies in the end panels formed from gold-finished, geometric-patterned Embossed Amerstrip. This effective pattern was created by famous industrial designers, Raymond Loewy Associates, and was rolled by American Steel & Wire.

The USS Embossed Amerstrip was given a No. 4 temper which is especially suitable for formulation work. It was rolled to .0239 inch thickness and trimmed to 5⅞ inch width with a No. 3 slit edge. So that the strip would make a good bond with the gold plate it was supplied with a No. 3 finish—the best finish available on strip. It is guaranteed against surface defects and has a sufficiently high lustre to make buffing or polishing before plating unnecessary. To protect the finish and the embossed design, the coils were interleaved with rolls of paper before shipping.

American Steel & Wire specializes in the rolling of special embossed designs for specific applications. If you have a product which could be made more beautiful or more sales-appealing with Embossed Amerstrip, get in touch with American Steel & Wire. Write to 614 Superior Avenue, N.W., Cleveland 13, Ohio. *USS and Amerstrip are registered trademarks*

American Steel & Wire Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal and Iron Division, Fairfield, Ala., Southern Distributors
United States Steel Export Company, Distributors Abroad

DEVELOPMENTS TO WATCH...

Insulating finishes with high electric strength . . .

. . . can be obtained by fluidized-bed processes (*PE*—Jan '57, p 140) says I. N. Ebling of Westinghouse Research Laboratories; and, he reports, heavy coatings can be deposited with a single dip, even on sharp, 90° knife edges where as many as 5 dips in a conventional solvent-thinned enamel are required.

Tests of one-dip fluidized epoxy, nylon, and low-density polyethylene coatings on steel panels showed electric strengths in the 1300-1700 v/mil range on flat surfaces and 1700 to 3100 on knife edges. (The high-scoring material in each case is the polyethylene, with epoxies the lowest and nylon in the middle). In contrast, conventional red alkyd enamels showed a flat-panel breakdown strength of 1528, and no strength at all on knife edges with less than 5 dips.

Furthermore, Ebling pointed out in a report to the Federation of Paint and Varnish Production Clubs, the fluidized-bed process provides excellent adhesion and permits use of insoluble resins.

However, he cautions, the process requires close control; thin, uniform coatings are difficult to obtain; and masking also presents problems.

Improved lubricants are expected to come . . .

. . . from an Esso Research & Engineering study of the elasticity of oils. As Esso researchers point out, oils under high stresses and high rates of shear exhibit elastic (non-Newtonian) behavior; and, they believe that, by learning more about this phenomenon, it will be possible to develop oils that produce less friction and less wear.

To study the problem, they're putting a whole laboratory full of instruments to work; among them: ultrasonic transducers, torsion pendulums, pressure viscosimeters, and rheogoniometers.

The transducer unit is a high-frequency vibration source that creates the shear conditions leading to non-Newtonian (elastic) behavior. By measuring the electrical resistance of the transducer crystal and the frequency shift which takes place when it is immersed in the oil, both elasticity and viscosity can be calculated.

The torsion pendulum is for lower-frequency studies, the viscosimeter for high-pressure tests, and the rheogoniometer helps Esso researchers study unusual stress effects.

A flowmeter that compensates for variations in density . . .

. . . caused by temperature changes, is being developed by Armstrong Whitworth Equipment, Gloucester, Eng.

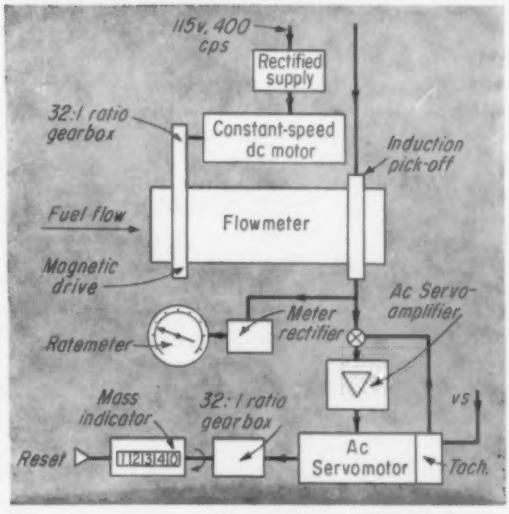
The device has an impeller and torque-measuring turbine that first impart angular momentum to the fluid being measured and then remove it—the torque needed to do the job being proportional to the mass flow. And, says A-W, it's accurate to within 1%.

The impeller, a tubular unit with vanes parallel to the direction of flow, is driven by a constant-speed dc motor from a rectified 115-v, 400-cps supply. The impeller is magnetically coupled to the motor drive and runs at a steady 100 rpm.

The turbine, similar in design to the impeller, is spring-restrained so that the turbine will rotate until spring and fluid torque balance.

An induction pickoff converts the angular deflection into an ac voltage output which is fed, through a rectifier, to a ratemeter and also into an ac integrating counter.

Prototype models have been built and the unit will soon be in production.



Flowmeter circuit is diagramed here. Complete unit weighs less than 12 lb; and metering unit alone, only 4.

DEVELOPMENTS TO WATCH...

The second stage of power generation . . .

. . . is getting the spotlight now. The first stage—the "furnace" and boiler—has been receiving the lion's share of attention, with exotic fuels, nuclear energy, and solar energy all under consideration.

Now, the second stage—normally occupied by turbine and generator—is getting a new look. Government and industry groups are exploring "direct" conversion systems based on Peltier and Hall effects (*PE*—May 4, p 28) and indirect systems using heat from nuclear or fossil fuels to produce hot, ionized gases through which a current can be made to flow. These MHD (magnetohydrodynamic: *PE*—Sep 23 '57, p 17) systems, as recently displayed by Avco and GE, promise gains of 25% or more in efficiency of fuel utilization—but pose equally great problems. Best estimate on large-scale commercial application of the Avco system, or space flight via the GE method, is "several decades from now."

The biggest problem in the power field still lies ahead, though: cutting the cost of distribution.

Honeycombs crush better than foamed plastics . . .

. . . and that's a recommendation when it comes to impact-absorbing screens for instruments and personnel, says NASA. Researchers at the NASA Langley Field Center have been testing several materials, using a simulated parachute landing (a 14-ft drop into sand) as basis for comparison.

Rigid plastics foams, they report, are too rigid. These materials become so stiff after about 60% of their thickness or depth has been used that they no longer serve as a cushion.

Semirigid foams are soft enough to provide a cushion, but often so resilient that rebound becomes a serious problem.

In contrast, aluminum honeycombs exhibit very little rebound and up to 80% of their depth is usable. But, the initial impact may be severe owing to the solid structure of the honeycomb skin.

Best material for the purpose may turn out to be a combination of the two—a sandwich containing both honeycomb and foamed or semirigid plastics.

Bearings that last longer . . .

. . . are promised by a series of government-industry research programs now underway.

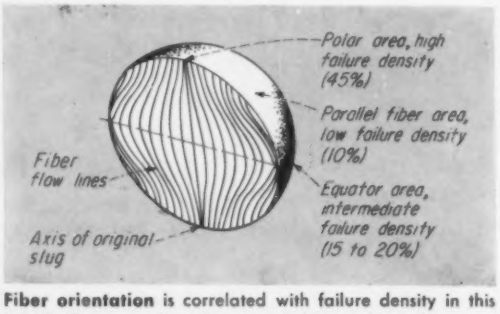
Following a finding by NASA researchers that orientation of the grains or "fibers" in the bearing metal appreciably affects the life of the rolling element (*PE*—June 1, p 9), that agency is continuing its own research, and is sponsoring research in industry as well. NASA is concentrating on the role played by material hardness, lubricants, and the effect of sliding in a nominally rolling contact. Sponsored research includes such projects as development of manufacturing processes capable of producing material which does not contain the low life areas now associated with end-grain orientation (see diagram).

As NASA originally pointed out, balls and races are made of steel which has been forged or rolled so that it has a definite crystal or "fiber" orientation which affects bearing fatigue life.

There are two explanations for this:

One, that the reduction in fatigue life is traceable to the inherently weaker structure of a porous (fibrous) surface. The surface discontinuities in the area where the grain is cut (the "polar" or "end-grain" area) are thought to produce stress-raisers which result in a level of effective stress considerably higher than in the parallel-fiber area.

The second theory traces the effects to impurities in the ingot from which the ball is made—impurities concentrated in the polar areas.


Polar area, high failure density (45%)
Parallel fiber area, low failure density (10%)
Equator area, intermediate failure density (15 to 20%)
Fiber flow lines
Axis of original slug

Fiber orientation is correlated with failure density in this NASA diagram. Note how much larger the failure percentage is where grain edge is presented to the contact.

Marlin-Rockwell Corp, one of the companies working on this aspect of the problem, is now testing balls made by 4 different methods—each aimed at producing a different grain pattern. They include shearing, pinch-off and kneading techniques.

Says Arthur S. Irwin, M-R director of research: "While fiber orientation certainly is not the only variable of a metallurgical nature, it is a pertinent one and one which, when investigated, can be eliminated or corrected for in the analysis of test results." —ARG

Foreign Competition Increases but Not Alarmingly—THE FACTS

After World War II, a battle-damaged world beat its way to the US market for the raw materials and machines to rebuild economies. During this period US exports had wide margin over imports, and our government initiated many foreign-aid programs. Now the economies are rebuilt and the European trade tables have turned.

During the second quarter of this year, US imports exceeded exports. Does this suggest the US has built a giant that now threatens to outsell us? Here, from McGraw-Hill World News, is an analysis of developments in the fields of interest to PRODUCT ENGINEERING readers—the new products, the industrial potential and trade objectives of our overseas competitors.

NEW YORK—Imports of foreign mechanical and electrical products have followed the general upward trend lately, but PRODUCT ENGINEERING reporters overseas cite three reasons why the shift in America's trade balance (see table) need not alarm manufacturers in these fields.

First, most European exports of this kind are special products for markets that are too small for US mass-production techniques. They require craftsmanship, and thus complement rather than compete with US products.

Second, US companies now own many manufacturing plants in Europe, South America and some in Japan. World marketing conditions indicate that this practice will continue to grow. US-designed products manufactured overseas are traded in the world market; some are imported by the US. One Britisher has commented wryly that the greatest threat the US faces is from its own companies in Europe.

Third, most European firms hesitate to make a direct assault on the US market because of the high cost of getting started plus the threat of tariffs that erase any price edge.

Shift in US Trade Balance
(in millions)

	Jan-Aug 1959	Jan-Aug 1958
Imports (Over-all)	9740	8211
Imports (Machines & Vehicles)	1056	720
Exports (Machines & Vehicles)	4005	4403

AREAS OF CONFLICT

There is some head-on competition. Swedish office-machine makers are fighting hard to increase their share of the US market and one manufacturer, Sweda Cash Register, is marketing half its output in the US. Competition also is likely to arise in the computer market. French computer-maker Bull hopes for a 5% slice of the American market with the Gamma 60, first computer claimed to permit parallel or simultaneous operation.

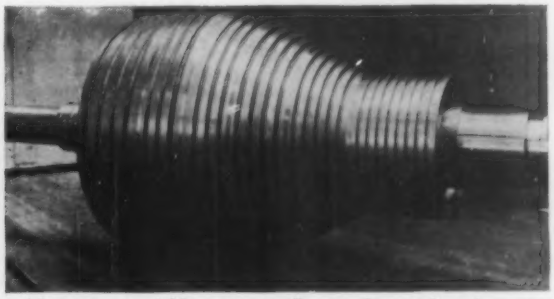
But by and large, European imports are complementary to US products. British machine tool companies have succeeded in selling small lathes—with all-geared heads instead of belted systems as in the US—and small radial drilling machines to US firms. These models, which account for about one-half of British machine-tool exports to the US, are not particularly sophisticated, but can be readily adapted to attachments such as copying equipment. They are said to be of better quality than anything that can be produced in the US for the price.

German machine-tool makers sell custom-tailored or multipurpose units here. They are predominantly for jobs off the regular assembly line. In other words, German machines fill the gaps left by mass production. In construction equipment, the Germans hope to revolutionize US building practice with their giant 350-ft tower cranes. The Germans say that they are the only producers of such equipment now, though rumor has it that Harnischfeger Corp of Milwaukee is working on a prototype.

French refrigerator manufacturers are hoping to break into the US appliance market in coming months (*PE—May 25, p 24*). But they will concentrate on small units for bungalow, boat, trailer and office. About half of France's electrical equipment sales to the US are aircraft batteries and radio broadcast tubes that have no real counterparts here. And construction equipment, caisson foundation diggers and small power shovels also have no US equivalents.

US TECHNICAL MIGRATION

A striking development in recent years has been the persistent migra-



Welded rotor . . .
A Swiss challenge—Brown-Boveri's heavy steam turbine rotors before and after assembly. The company says its continuous welding process yields a structurally sounder product than one-piece rotors common in the US. The process eliminates costly rejects and permits company to cut production costs sharply.

tion of American capital to foreign countries. US direct investment overseas in plant and equipment has been running well over $2 billion annually for the past three years and should run $2.1 billion next year *(PE—Aug 17 p 21)*. About 40% of next year's investment will be in Europe; a large portion of the remainder in Africa and Asia.

The reasons for such heavy overseas investment go beyond the desire to support US foreign policy. US companies are anxious to locate within geographical trade areas that will eventually be protected by tariffs and possibly import quotas. The Sterling area—United Kingdom and certain Commonwealth countries—drew a large number of American companies to England after the war. More recently the common market (France, West Germany, Belgium, the Netherlands, Italy and Luxembourg) has been attracting US industry to the continent. And just last month another similar area opened up when England, Sweden, Norway, Denmark, Austria, Switzerland and Portugal formed the "Outer Seven."

US firms are also anxious to take advantage of the lower labor and other production costs in Europe, particularly since they are competing with European firms on standard items such as typewriters in the South American and Asian markets. Many US companies are improving their domestic competitive position by sending assembled machines or components back to the states.

TYPEWRITERS TO TRACTORS

A typical example of US foreign investment is the clique of typewriter manufacturers in the Netherlands. Royal-McBee has two plants—one for manual and electric typewriters; the other for lightweight, inexpensive portables, the Royalites. Both are sold throughout the world, and the Royalite is sold in the US. Remington-Rand at present is making a portable typewriter in the Netherlands for sale on the world market, and components for assembly in company plants located in other continents. Some are sold in the States.

Monroe Calculating Co has a plant in the Netherlands for manufacture and assembly of hand and automatic calculators. These are shipped to all parts of the world and are identical in design with units made in the US.

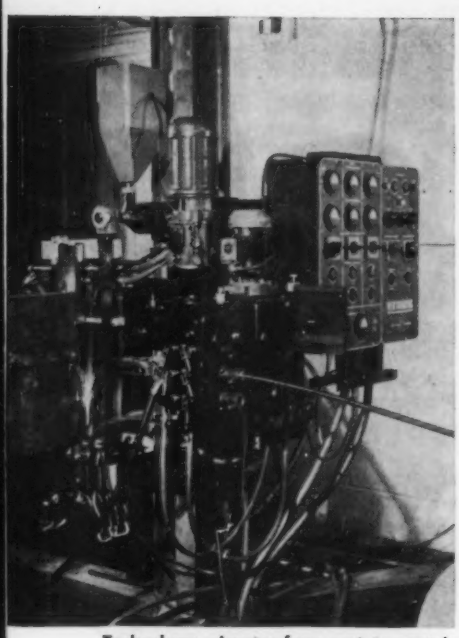
The US is one of Britain's largest customers for tractors. Exports this year should treble—to 10,000 vehicles. The largest tractor manufacturers in Britain are Ford and International Harvester. Two of the Ford tractors are now available in the States: the Fordson Power Major with a 4-cyl diesel engine and 6-speed transmission; and the Dextra, a very small utility tractor with 3-cyl diesel and 6-speed transmission. They complement the US Ford line and are cheaper than similar Detroit units.

In machine tools the British firm, Giddings, Lewis and Fraser Ltd, 51% owned by the US firm, Giddings & Lewis, has the rights to market American-designed horizontal borers in the US, but as yet has made no attempt to do so. The British subsidiary has worldwide selling rights of Giddings & Lewis equipment and is currently making a big effort to sell Fraser-designed machines in the US.

Many European companies are reportedly shipping components to the States. Massey-Ferguson, England, exports about 20,000 gearbox and rear-axle assemblies to Massey-Ferguson Co, Milwaukee, annually. Cummins Engine Co in Britain says it sends finished-machined major castings and forgings, including pistons, crankshafts and bearings to the States, although the US firm denies this. IBM's French plant is shipping components for tabulators and computers to the States, at lower costs.

US investment in Japan is negligible, probably less than $50 million in manufacturing plant. But eased restrictions on foreign investment by the Japanese government will probably encourage more. Some of these products will likely head for the States. An agreement between Daystrom Inc, and Nichimen Co Ltd of Osaka, concluded this fall typifies an emerging pattern of technical-manufacturing cooperation. The company, 50% owned by Daystrom, will ship electric and electronic components to the US

Industrial and consumer goods . . .
American industrial genius is taking root in foreign lands. At left, a Fordson Major diesel tractor manufactured by Ford in England. This low-cost utility model is for applications that do not require hydraulic lift and 3-point implement linkages. Portable typewriter at right is made at Cuyk, Holland by Royal McBee.



Technology migrates from east to west in unusual licensing sequence. Electro-slag welding equipment bears control equipment developed in Czechoslovakia. Czech firm licensed product to Arcos, Belgium, who in turn licensed it to Arcos, Phila.

company and import the assembled product. Eventually, according to Japanese reports, the company will manufacture the product in Japan

AUSTERITY THROUGH INGENUITY

In most European countries, factory rentals, wage rates and other production costs are lower than ours, but shorter production runs generally cancel part of the price advantage. Ingenious designs that conserve materials also cut their production costs. Even with custom design, European manufacturers feel that they can compete with US products where tariffs are not a factor.

Brown-Boveri, Swiss manufacturer of electrical equipment, primarily a custom supplier, retains its competitive position by limiting nonproductive workers—legal, advertising and public relations staff—and by careful design to economize on materials. Company engineers, for example, have developed a method for building up turbine and generator rotors from small sections that are welded together instead of casting them in one unit. When a material flaw is discovered, only a small section need be discarded. The company has also developed very compact rectifiers; an 8000-kw assembly weighs only 4500 lb. Instead of including two or more transformers, as is customary, they have combined four transformer functions—phase shifting, regulating transformer, rectifier transformer and commutator reactors—in one unit.

The reasons for low production costs in Italy go beyond low wage rates. Autos, for example, contain considerable salvaged steel plate. This steel has a yield point of 28,000 psi compared with 40,000 psi for most US autos. Current-carrying parts are also mounted on thermoplastic materials—a procedure that is frowned upon by US standards. Moreover, Italian designers save materials by combining several functions in a single part. Radios, for instance, are designed into driving mirrors.

MASS PRODUCTION IN EUROPE

Emergence of the Common Market in Europe, with potential tariff-free access to 165 million people, and the Outer-Seven area with 90 million people, is making mass-production techniques of the US increasingly attractive to Europe. Economies from long production runs and modern production equipment will stiffen competition for US products in the world, if not in the home markets.

Burroughs Corp is building a plant at Villers-Ecalles to fabricate and assemble 10-key adding machines. Production costs, the French say, will be 40% lower than in the US. Tooling concepts and assembly methods are based on US practice. The equipment in the plant was supplied mostly by France, with some coming from Britain, the US and Germany.

Italy is apparently looming as a world competitor in transistors. It has hopes for underselling American producers and offering better quality than the Japanese on automation. Five firms are presently dominant: FIVRE: 50% owned by Sylvania; ELSI—Raytheon licensee; SGS—International GE licensee; GTSF—licensee to France's Compagnie Generale de Telegraphie sans Fils; and Philips SPA—affiliate of Dutch Philips

In Holland, Van Doorne's Automobilefabrieken is using transfer machines and other automatic equipment for a production line that is eventually expected to turn out 200 cars per day. (It's predicted this production run will find a market for 30 to 40% of company production—about 20,000 cars—in the US.) The equipment came primarily from Germany and Switzerland.

The Swiss watch business is yielding to automation in some part. The Gruen watch company—a US-owned firm—is automating basic processes as far as possible to cut manufacturing costs. One part which formerly cost 40¢ now costs about 10¢.

In the near future the US seems likely to retain its position as one of the world's leading suppliers of engineered goods. But Europe will be an increasingly effective competitor. One Italian industrialist predicts stiffer competition from his nation based on modernized equipment and introduction of production and marketing techniques by the US firms, Mead-Carney, Ebasco, Booz Allen & Hamilton, Bruce Payne and McCann Erickson. His prediction becomes especially graphic now that one of his country's firms is bolstering an old-established US firm. Just recently Olivetti announced that it has agreed to invest $9 million in Underwood Corp for modernization of plant and equipment in the States. ■

WASHINGTON—A new 2-year agreement signed by the US and the Soviet Union will spur exchange of visits by each nation's scientists and engineers to observe key industries such as automotive, commercial aircraft, ship-building, railroads, and petroleum. The new pact is an extention of two previous 24-month agreements beginning in 1957. Program calls for delegations of five to ten persons to make the journeys.

The agreement is highlighted by a clause that provides for US delegations to study USSR management methods in exchange for a USSR team being permitted to observe US refrigeration techniques. The two sides also agreed to make specific proposals for joint projects in peaceful application of atomic energy and to provide for exchange of scientists in this field as well as in the fields of education and communications. ■

Weld Strength Comparison (carbon steel plate)

Process used to deposit weld metal	Tensile Strength, psi x 1000	Yield Strength, psi x 1000	Elongation % in 2 in.	Reduction in area, %
E 6010—E 6011 Electrodes	62–73	52–61	22–28	35
Flux Cored Wire CO_2 (51)	61–72	52–58	20–32	35–65
Solid Wire—CO_2	63–73	52–57	20–30	35–60
Solid Wire—Argon + O_2	64–71	52–56	26–33	27–65
Submerged Arc	60–70	50–55	25–35	40–70
Vertomatic—48 wire	62–66	40–46	28–32	60–75
Plate properties	60	40	35	65

Electroslag Welder from Soviet Speeds Joining of Heavy Sections—Is Now Available Here

PHILADELPHIA—An outstanding development of Russian welding technology, the electroslag welder has been brought to this country by Arcos Corp, via an agreement with the Czechoslovakian government (see page 23). The new automatic welding machine, called Vertomatic by Arcos, can continuously weld—in one pass—plate and forgings from 1½ in. to more than 10 in. thick. Welding time for such sections can be cut as much as eight times, compared to conventional submerged-arc welding used here.

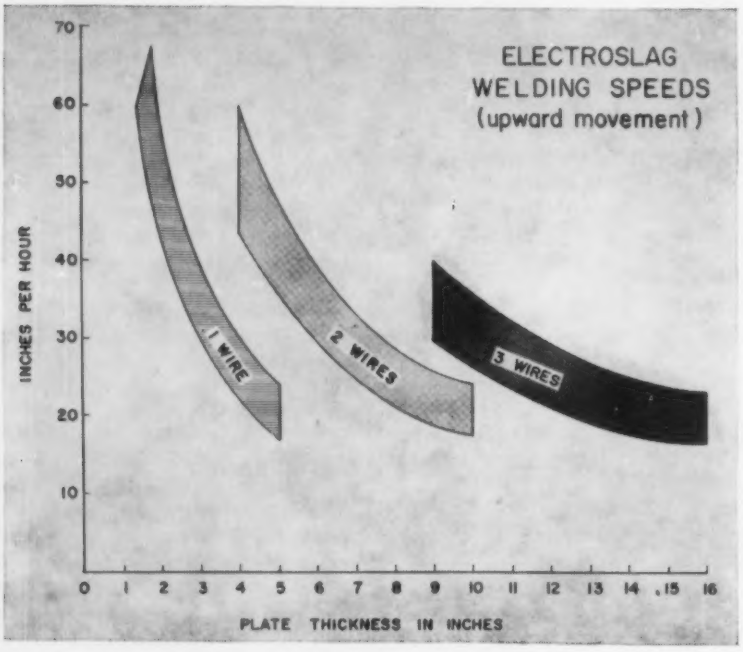
Electroslag welding (*PE—Jan 19, p 64*) was developed by the Russians to build large structures impossible to form on existing Soviet forging presses. In the arc-less process, an electric current flows through a pool of molten slag. Resistance of the slag creates high heat—melting both filler wire and parent metal. Welding is done in vertical position, with the machine rising automatically as the melt cools and solidifies—somewhat analogous to pouring a concrete smoke stack with rising forms.

Equipment is readily adaptable to tee and angle joints, as well as butt joints. Multiple-wire feed is used for thicknesses over about 4 in. (see welding speed curves). Tests on weld joints made here so far show strengths comparable to those obtained by other welding techniques (see weld strength table).

After speed, economy appears to be the principal advantage of electroslag welding. Arcos engineers estimate that 2½-in.-thick sections of mild steel will cost about $8.50/ft and 10-in. sections only about $34/ft. At 10-in. thickness, the process uses 31% of the weld metal needed by submerged-arc welding for the same joints. These figures include the normal elements of cost: flux plus wire, current, equipment depreciation, labor and overhead.

Looking beyond welding of thick plate per se, Arcos experts see several intriguing possibilities for the process: joining heavy plate scrap; reinforcing beads on flat plates; joining large castings; cladding of heavy plate; joining of medium-sized forgings into larger structures—cutting need for heavy presses. This last, of course, is a leaf straight out of the Russian book.

Weldable materials so far include mild steel, stainless and Cr-Mo grades. Welding of low alloy-high strength steels that require quenching and tempering is being explored. To date, according to Arcos, main obstacle is the need for faster quench than electroslag welding provides. —Ford Park



FHA-type Loans to Pay for College?

ST LOUIS—Any student who wants to attend college may get his chance if Sen Johnson (D-Tex) has his way. In a speech prepared for a conclave at St Louis Univ, Johnson hopes to push through Congress next year legislation for FHA-type loans for students. He declared that the next 10 years may decide for the century "the war between freedom and tyranny."

The Federal government contributes to the support of educational activities only about ¼ of the amount per capita that it spends for the postal service, said Johnson. "We must put values of the mind first and therefore will sponsor legislation permitting the Federal government to insure educational loans to everyone who wants to attend a school of higher learning." ■

Plastics Evaluation Center Sponsored by Defense Dept

WASHINGTON—A large technical evaluation center for plastics, patterned after Battelle Memorial Institute's titanium center, is being sponsored for Army Ordnance by Dept of Defense. The center will be located at Picatinny Arsenal, Dover, NJ, and will serve persons and companies whose need for technical data in the area of plastics is directly or indirectly connected with defense. Picatinny Arsenal already has a full-scale laboratory for basic and applied research.

According to John R. Townsend, special assistant to the Director of Defense, Research and Engineering, this was the thinking that led to decision to support such a center:

Plastics have proved of extraordinary technical value in advanced design of missiles and are progressively gaining wide military use. This is of strategic importance to the Dept of Defense. The limitations of plastics are largely technical, an outstanding one being resistance to quality and performance standardization; and since most plastics firms are small, government action here seems most appropriate, Townsend reported.

WILL ISSUE REPORTS

The evaluation center will be staffed, in most cases, with research scientists whose primary interest is in research problems. Technical information will be collected, evaluated, stored and disseminated. For example, as with the Battelle operation, a highly trained technician may visit persons and companies engaged in government projects, may exchange data, offer technical assistance where it is possible, and return from the company with data and any questions posed.

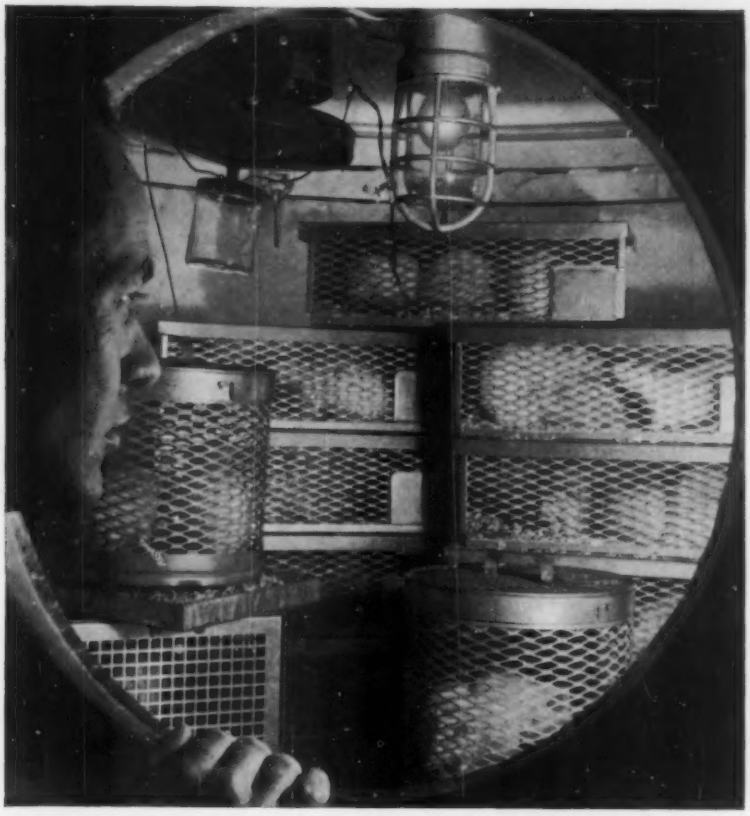
This information will be placed in the files after being studied by qualified experts at the center; may lead to laboratory research, or to a special report available to interested contractors and suppliers. Information obtained by the Center's technicians will include the latest development, engineering and application work in the field of plastics and reinforced plastics. There will be state-of-the-art reports on important and advanced technological aspects of plastic engineering. Encouragement will be given to work in standardization of processes, products, testing methods and materials. Questions initiated and posed by contractors and suppliers may form the basis for special reports issued by the center. Like Battelle, the Picatinny Center will occasionally issue papers of "somewhat more speculative, less complete and authoritative nature as a means of directing engineering attention to important but still-unsolved phases of development."

BENEFIT TO ALL INDUSTRY

Townsend said the Dept of Defense foresees the Center narrowing the gap between research and applied engineering. Engineering developments too often result in an accumulation of notebooks, records, working papers, internal staff reports and unrecorded data in the head of the head engineer, he said. This information may not be recorded for a year or more, if ever. The plastics center will alleviate this situation.

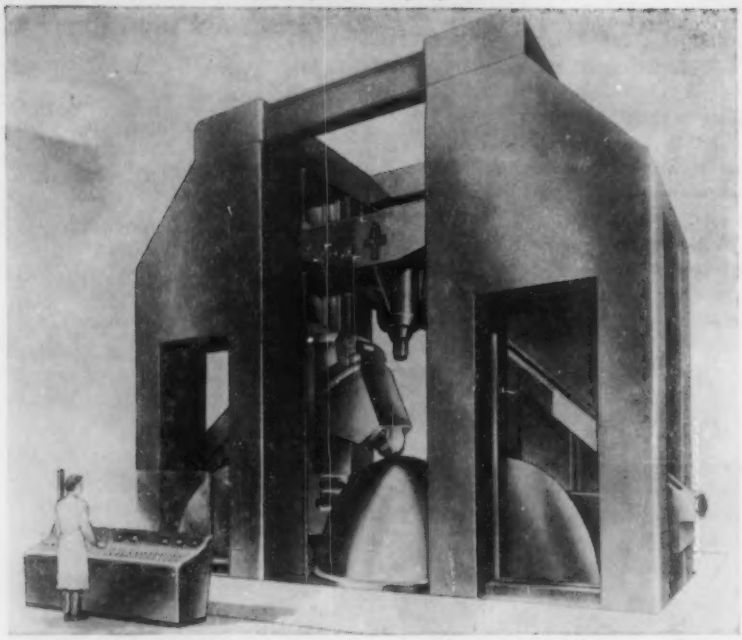
In the long-term future, Dept of Defense is optimistic that nonmilitary industry will benefit, and predicts gains beyond military applications reaching a variety of industries. ■

They Equal Metabolic Rate of 1-Man Crew



Cryogenic system of environmental control in a hypersonic aircraft or space crew compartment using 45 lb of lab rats is tested by Boeing Airplane Co. System calls for mixture of oxygen and nitrogen contained in liquid state in a single Dewar bottle; liquid is metered into crew compartment at a specified rate. Tests showed that at 15,000-ft altitude, with a sea-level oxygen partial pressure of 160 mm Hg, ratio of 59% nitrogen and 41% oxygen is most efficient. Oxygen and nitrogen were mixed by flowing the two fluids under pressure into a single transfer line. However, there was incomplete vaporization of the mixture on entering the cabin, so a drilled baffle was placed in the recirculated air stream for the liquid to impinge upon, restoring control over chamber environment. Boeing reports need for a more efficient method of mixing the cryogenic liquids, and a better means of properly vaporizing the liquid. System is designed to control compartment environment for a 2-to-6-hr period in flight.

Giant Forge to Shape Space Equipment



New 120-in. spin forge (largest in operation is a 72-in. machine) for forming missile and space vehicle components up to 10 ft in dia and 24 ft long will be completed by July, 1960. According to its builders, Siegler Corp's Hufford Div, the forge will measure 37 ft wide, 38 ft high, 22 ft deep and will weigh nearly 600,000 lb. Described as the only means of forming a number of parts used in missiles, rockets, and other space vehicles, the huge machine eliminates welds, increases strength of metal processed, reduces production time, and achieves extremely accurate tolerances and finishes. Spin forge utilizes a combination of rolling and shearing principles to produce mechanically spun sections with varying wall thicknesses.

Last Manned Aircraft May Be VTOL

NEW YORK—VTOL aircraft are in for a big boost if the planned Air Force design competition isn't knocked out of the budget. Funds for the design evaluation are understood to be available from the present fiscal budget, ending June 30, 1960. Designs are scheduled for submittal by the first quarter of 1960.

The vertical-takeoff fighter, if built, will probably be the last manned combat aircraft to be ordered by the Air Force. Already cancelled is the F-108 supersonic long-range fighter-interceptor project, and sharply cut back is the B-70 supersonic jet bomber. Although development work is to continue, funds for a nuclear-powered plane are out of next year's fiscal budget.

It's reported without confirmation that the Air Force will place a contract with the winner of the VTOL competition for two stripped-down prototypes which would be test flown and evaluated before the expensive fire-control and other combat equipment is added. The plane would probably be faster than present supersonic jet fighters.

Competition will probably be among Republic, Bell (in conjunction with Convair), Lockheed, Chance Vought, Douglas, Boeing, McDonnell. GE is also involved, based on engine design studies for vertical lift planes with high forward speeds. ■

New Spherical Bearings Need No Lubricant

DANBURY, CONN.—Self-aligning spherical bearings that feature a low coefficient of friction (0.04), without using lubricants such as film, graphite or molybdenum disulphide, have been reported by Radial Bearing Corp here. Teflon fabric is bonded directly to the outer raceway, Radial says, and tests show that the resulting bearings have 10 times the life of conventional bronze or steel-on-steel.

The firm reports that Teflon fabric not only has chemical inertness and resistance to heat degradation with a unique low-friction, nonsticky surface—but also has a high molecular orientation which gives toughness and strength. Result: the new bearings are suitable for low surface speeds, high unit loads or applications subject to high dynamic loading where metal-to-metal life is limited by fretting or brinelling.

These bearings have undergone dynamic testing for 2200-lb constant load at 50° oscillation (±25°), 13°/sec for 50,000 cycles and shown a wear characteristic of only 0.00035—all without lubrication. ■

COMING EVENTS

JANUARY

12-15 . . . . Society of Plastics Engineers, 16th Annual Technical Conference, Conrad Hilton Hotel, Chicago.

15 . . . . Malleable Founders Society, Semi-Annual Meeting, Hotel Sheraton-Cleveland, Cleveland, Ohio.

25-28 . . . . Plant Maintenance & Engineering Show, Convention Hall, Philadelphia, Penna.

27 . . . . Plumbing Brass Institute, Hollywood Beach Hotel, Hollywood, Fla.

FEBRUARY

2-4 . . . . Society of the Plastics Industry, 15th Annual Technical and Management Conference, Edgewater Beach Hotel, Chicago.

3-4 . . . . Armour Research Foundation, 6th Annual Midwest Welding Conference, Illinois Tech Chemistry Building, Chicago.

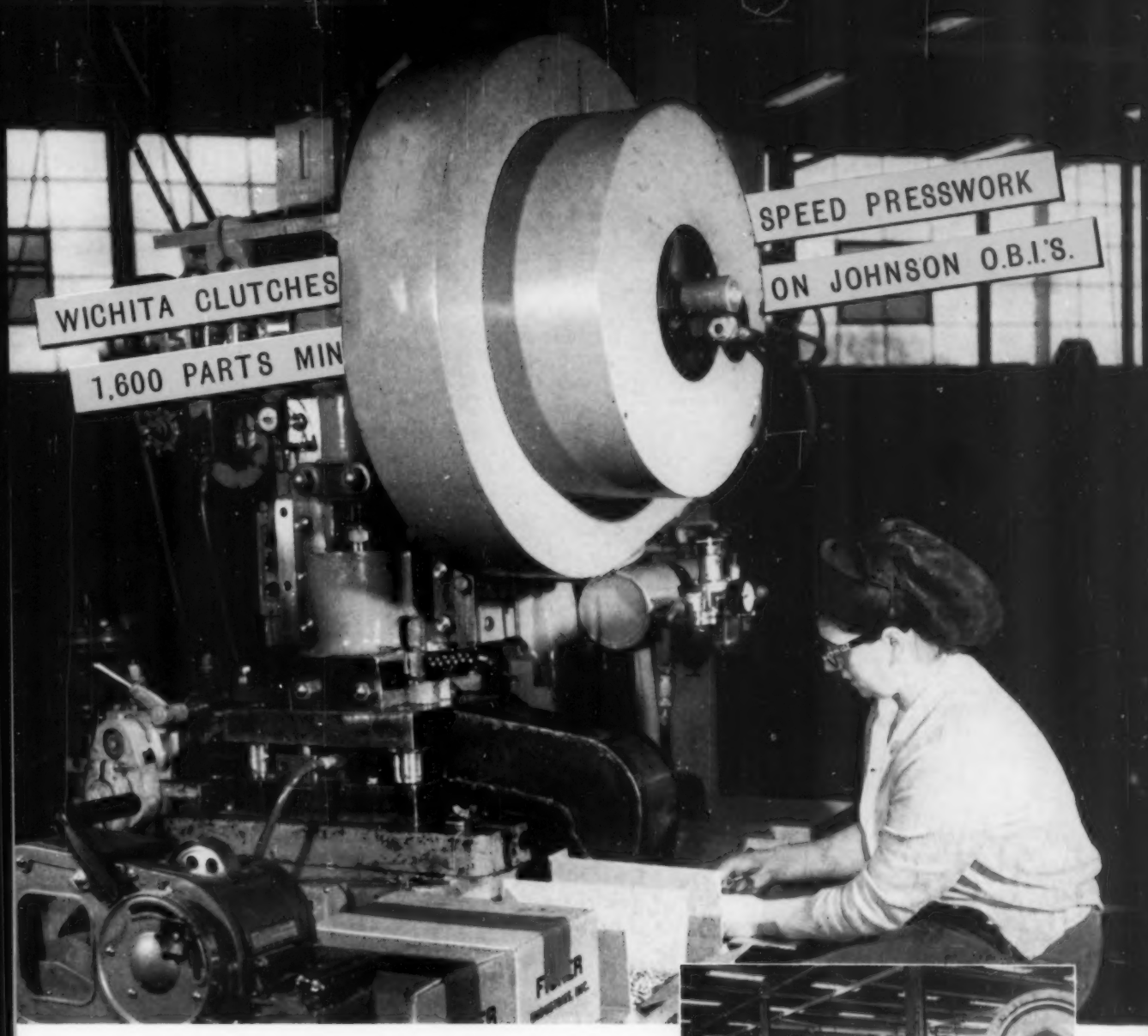
3-5 . . . . Institute of Radio Engineers, 1960 Winter Convention on Military Electronics, Ambassador Hotel, Los Angeles.

10-12 . . . . Institute of Radio Engineers, American Institute of Electrical Engineers, Univ of Pennsylvania, Solid-State Circuits Conference, Philadelphia, Penna.

24-25 . . . . Malleable Founders Society, Technical and Operating Conference, Cleveland, Ohio.

APRIL

20-22 . . . . Institute of Radio Engineers, 12th Annual Southwestern Conference and Electronics Show, Shamrock Hilton Hotel, Houston, Texas.



Battery of presses proves speed and dependability and saves on dies

Johnson Machine and Press Corporation selected Wichita clutches for the Model 4½ press shown above, one of a line installed at Fisher Industries, Inc., serving the automotive industry. The press shown above is one of two Johnson Presses rated at 330 strokes per minute that produced 200 million moulding clips in 18 months.

If you have a clutching or braking problem it will pay you to call in a Wichita Engineer to help you work out a profitable solution.

Contact your nearest Wichita Engineer!

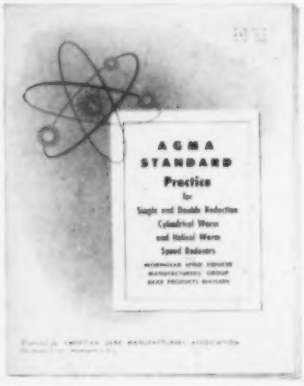
Clutch & Control Engineering Co., Livonia, Mich.
L. H. Fremont, Cincinnati, Ohio
W. G. Kerr Company, Pittsburgh, Pa.
Smith-Keser & Co., Avon, Conn., Philadelphia 44, Pa., and New York, N. Y.
Frank W. Yarline Co., Chicago, Illinois
Larry W. McDowell, Long Beach, California
Andrew T. Lobel, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
Norman Williams, Houston, Texas
Allied Transmission Equipment Co., Kansas City 8, Missouri
Donald E. Harman, Dallas, Texas
C. Arthur Weaver, Richmond, Virginia
Malcolm S. Cone, Memphis, Tennessee
Dominion Power Press Equipment, Ltd., Burlington, Ontario, Canada
R. E. Kunz, Seattle 4, Wash.
Norman Rupp Co., Portland 4, Ore.
Bates Sales Co., St. Louis 1, Mo.

WICHITA COMPANY, INC.

CIRCLE 27 ON READER SERVICE CARD

DE LAVAL offers new A.G.M.A. Gear Standards Booklet for Engineers

You will not want to be without this newly published American Gear Manufacturers Association booklet. It outlines the new standards for single and double reduction cylindrical worm and helical worm speed reducers.



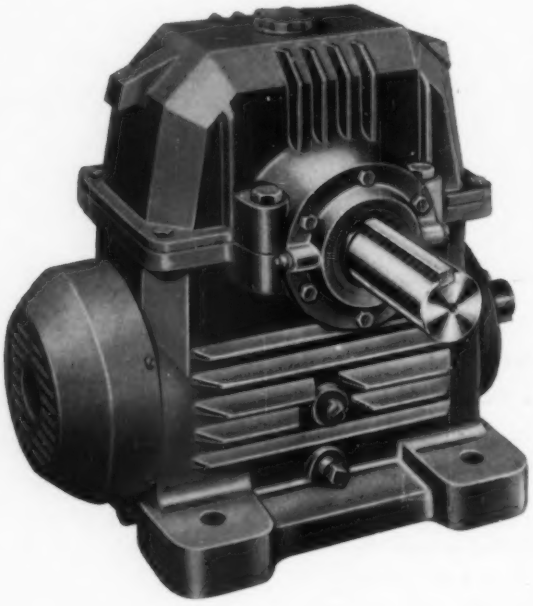
Get this new A.G.M.A. 440.03 booklet free of charge by request on your company letterhead.

This new standards booklet contains important design data including: Power rating of worm gears • Ratio correction factor (Km) • Materials factors (Ks) • Velocity factor (Kv) • Coefficient of friction(μ) • Thermal factor • Service factors • Efficiency • Overhung load capacity • Lubrication.

The materials factor (Ks) and the coefficient of friction (μ) are new, reflecting the latest advances made in worm gearing in the past few years.

We have also recently published our new Delroyd Worm Gear Sets Catalog 3800 and Delroyd Single Reduction Worm Gear Catalog 3805, which contain comprehensive information on the selection of these units.

De Laval furnishes worm gearing under the trade name DELROYD and has a complete line from $1\frac{1}{8}$" to 36" center distance, in horsepower ranges from .04 to 700 and in ratios from 5: to 4900:.



DE LAVAL *Steam Turbine Company*

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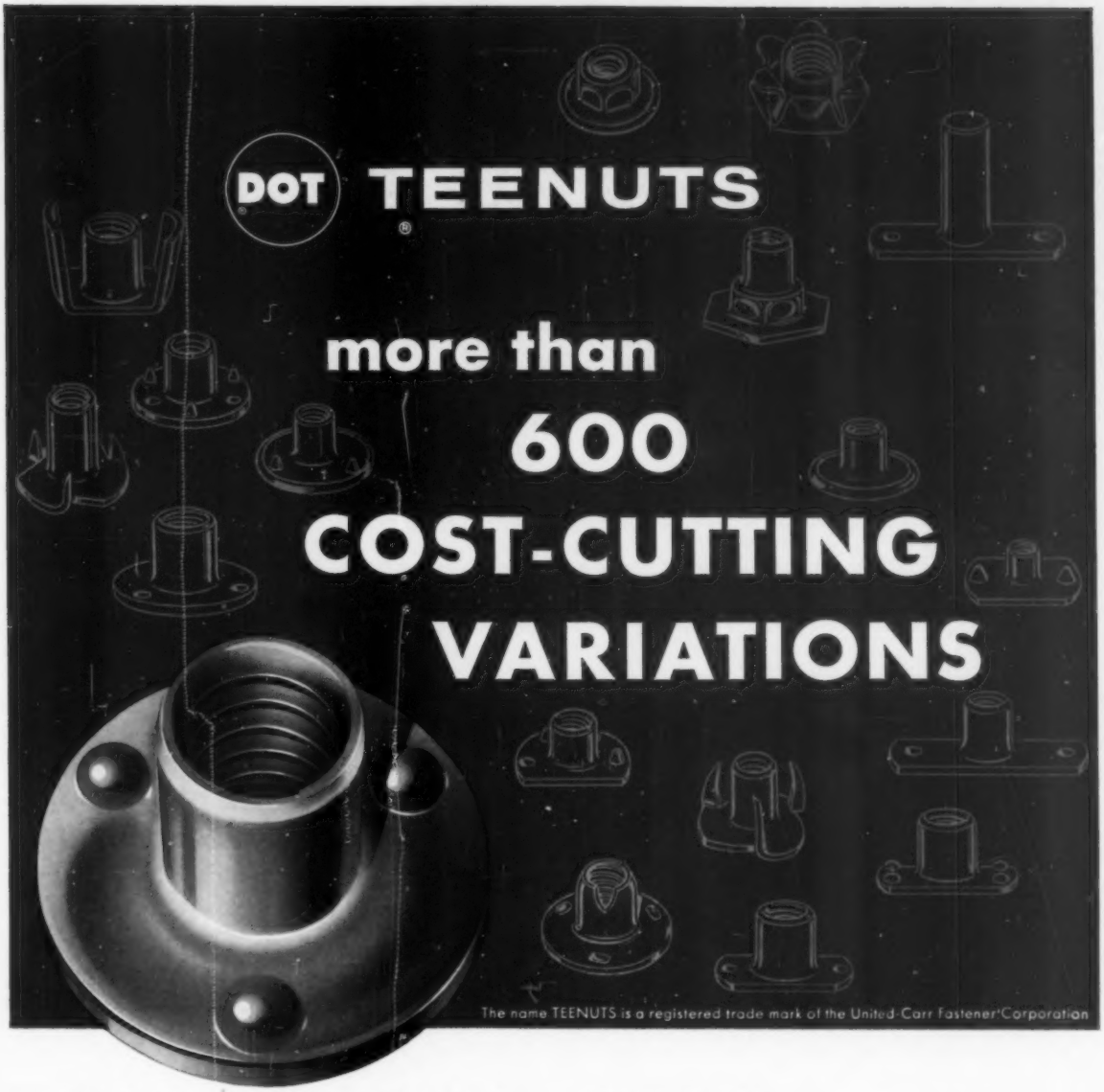

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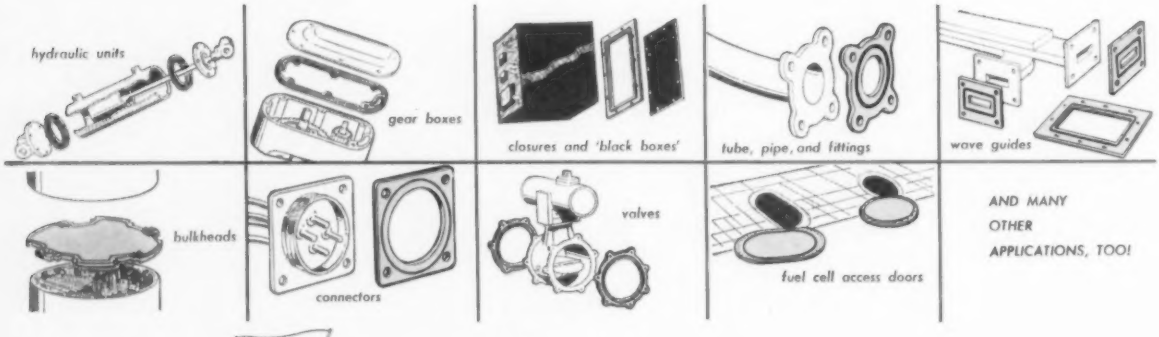
Safe, sure sealing is vital in today's high performance machines, aircraft, missiles, ground support equipment and processing equipment and *there* is a better way to seal them . . . GASK-O-SEALS.

The Gask-O-Seals shown here are static seals that can actually provide sealing that will exceed hermetic top specifications. Yet, they are mechanical, can be removed, and reused. *Controlled confinement* of the rubber makes them superior to other seals.

The "typical" applications shown are just a few of the ways Gask-O-Seals are being used. Practical, *truly* economical, no-leakage sealing. If you want to *seal* for *sure*, find out about Gask-O-Seals. Just drop us a line or use the reader service card.



Parker SEAL COMPANY

CULVER CITY, CALIFORNIA and CLEVELAND, OHIO

A DIVISION OF PARKER-HANNIFIN CORPORATION

PRESSURETROL*
PRESSURE CONTROLLERS

Here are new additions to Honeywell's broad line of pressure switches designed specifically for industrial use. Use them for reliable, economical control of liquid or gas pressure—alone as controllers, or with other instruments for limit alarm or signalling service.

1. MODELS P428A, B, C, D FOR CONTROL OF PRESSURES TO 3000 PSI

These *Pressuretrols* consist of a single-pole, single-throw mercury switch operated by a corrosion-resistant Bourdon tube. The case is designed to harmonize with other instruments, and is ideal for use in panels. It is compact, of drawn steel with a die-cast cover, and resists dust, weather and corrosion. The *Pressuretrol* can be surface or flush mounted on a panel or installed directly on a pipe. Pressure settings are made with two knobs conveniently located on the face of the unit.

SPECIFICATIONS

MODELS: P428A, standard case, spst, breaks circuit on pressure rise.
P428B, standard case, spst, breaks circuit on pressure fall.
P428C, explosion proof, spst, breaks circuit on pressure rise.
P428D, explosion proof, spst, breaks circuit on pressure fall.

Pressure Ranges	Maximum Pressures	Bourdon Tube
30— 300 psi	375	Bronze or stainless steel
50— 600 psi	750	Bronze or stainless steel
100—1000 psi	1200	Beryllium copper or stainless steel
200—2000 psi	2400	Beryllium copper or stainless steel
300—3000 psi	3500	Beryllium copper or stainless steel

2. MODELS P444A, B FOR INDEPENDENT HIGH AND LOW PRESSURE SETTINGS

Use these *Pressuretrols* in a wide variety of industrial applications that call for independent high and low pressure settings and switching action. A pressure-actuated, corrosion-resistant stainless steel diaphragm positions a mercury switch according to selected pressure settings. The mercury switch, scale plate and pressure setting indicators can be easily seen through a protective glass window in the cover. Pressure setting handwheels extend through slots in the cover. Adaptable for either surface or flush mounting.

SPECIFICATIONS

MODELS: P444A, standard case, spst, breaks circuit on pressure rise.
P444B, standard case, spst, completes circuit on pressure rise.

Range	Maximum Pressure
20" vac.—40 psi	75 psi
1—20 psi	50 psi
5—60 psi	80 psi
5—150 psi	200 psi

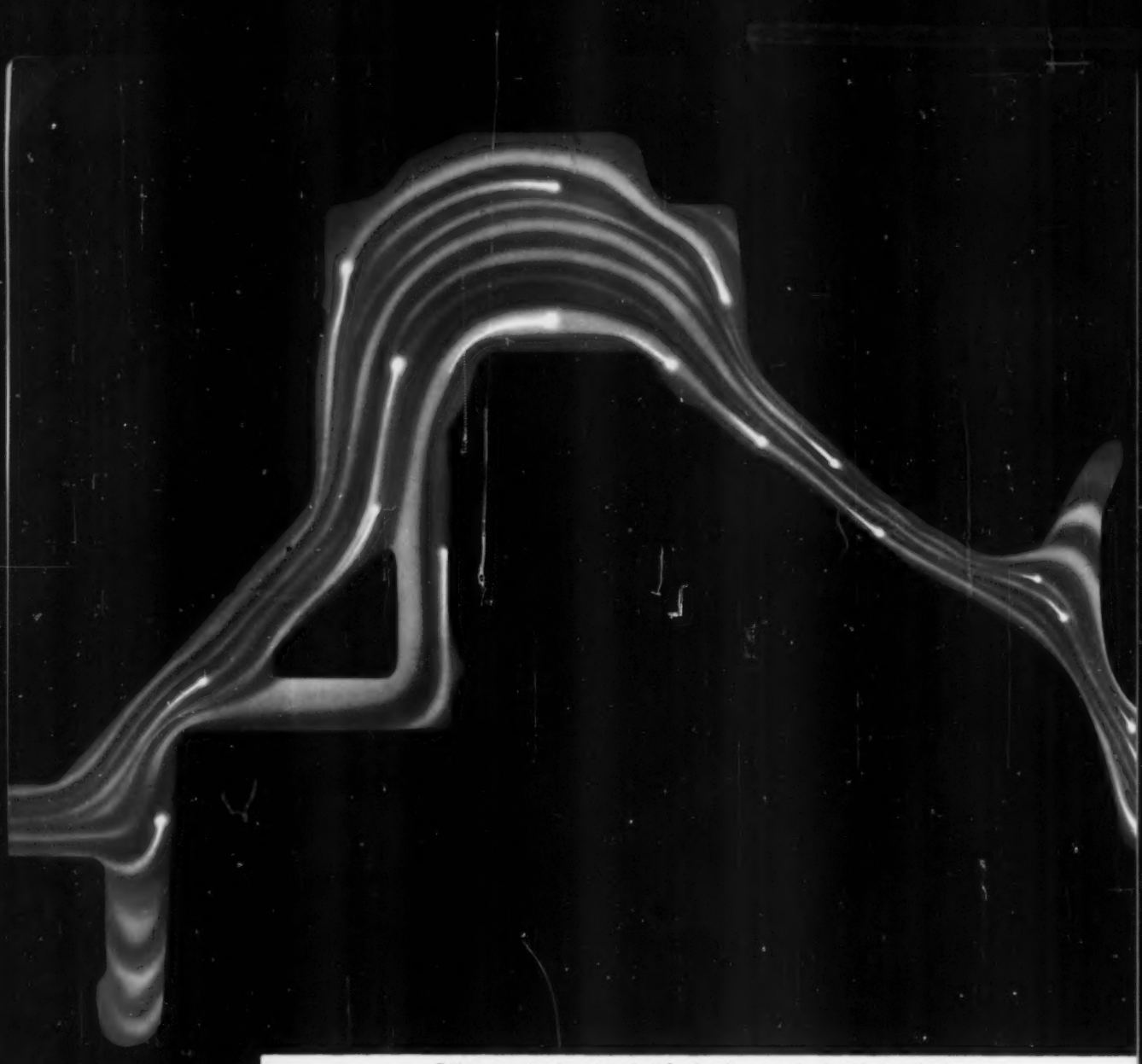
Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

*Trademark

Honeywell

First in Control



Fluid mapper pattern demonstrating liquid flow through a cross section of a Malleable differential carrier.

Versatility is Malleable

The ability to do most any job well is synonymous with Malleable iron castings. The variety of tasks they perform, from the commonplace to the spectacular, is legend. The strength and toughness . . . the freedom of design . . . the wide range of shapes and sizes . . . the excellent machinability . . . the economies achieved . . . all these advantages of Malleable combine to create an unexcelled reputation for versatility.

Whatever your needs, look first to Malleable.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

Versatility Is Key to Malleable's Increasing Use

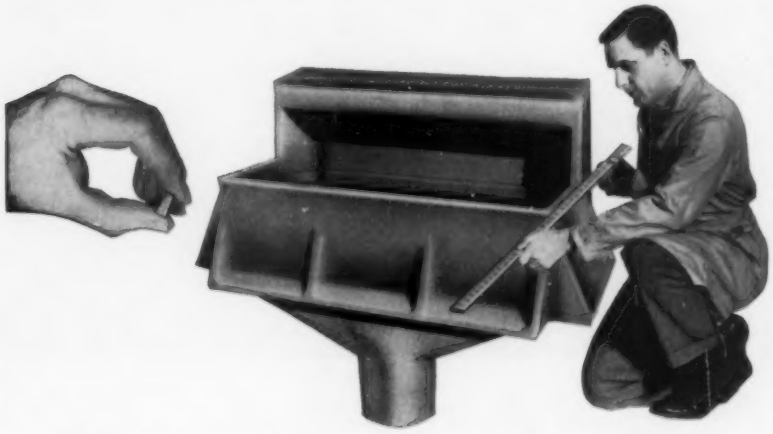
Recent metallurgical advances have made the Malleable irons a family of metals uniquely capable of meeting the most diverse design, production and performance requirements. Whether the vital consideration is high strength, toughness, ductility, hardness, machinability, high or low temperature performance, wear resistance, or economy and adaptability for complicated designs, Malleable castings have the versatility to meet exacting specifications.

For versatility of shape, the casting process is unexcelled. It permits direct production of the most complicated components. The metal is placed exactly where it is needed regardless of the intricacy of the design.

The capabilities of the metal to be cast are of even greater significance, for every application has a different set of requirements. Here, Malleable iron provides unique opportunities to obtain better parts at less cost.

Holes can be punched in Malleable, surfaces can be coined to meet rigid specifications. The pearlitic Malleables can be surface-hardened for even better wear resistance. These and other advantages make today's Malleable iron one of the most versatile engineering materials available.

Although Malleable iron's properties are flexible, depending on service requirements, certain relationships remain constant. Malleable provides more strength and toughness per dollar than any other metal. It is also the most machinable of all ferrous metals of similar properties.



Malleable castings can be produced in sizes ranging from the hammer handle wedge, shown here, weighing less than an ounce, to the 1,125 pound bridge scupper. Throughout this range is an endless variety of castings, best made of Malleable for highest quality at lowest cost.

Shapes and sizes of Malleable castings are virtually limitless. The combination of Malleable's good castability with modern production techniques regularly results in sections as thin as 1/16″ and tolerances of ±.005″ per inch in sections of 1″, with excellent surface finishes.

Engineering Aids Available

While the design of Malleable castings is not complicated, it will pay you to consult a skilled Malleable engineer who can offer time and cost saving suggestions for the production of better parts. As another aid to basic Malleable casting design, a special folder — *Data Unit 104 — Design Versatility* — is available from any member of the Malleable Castings Council and from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

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Eastern Malleable Iron Co., Wilmington 99

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Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
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Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

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Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

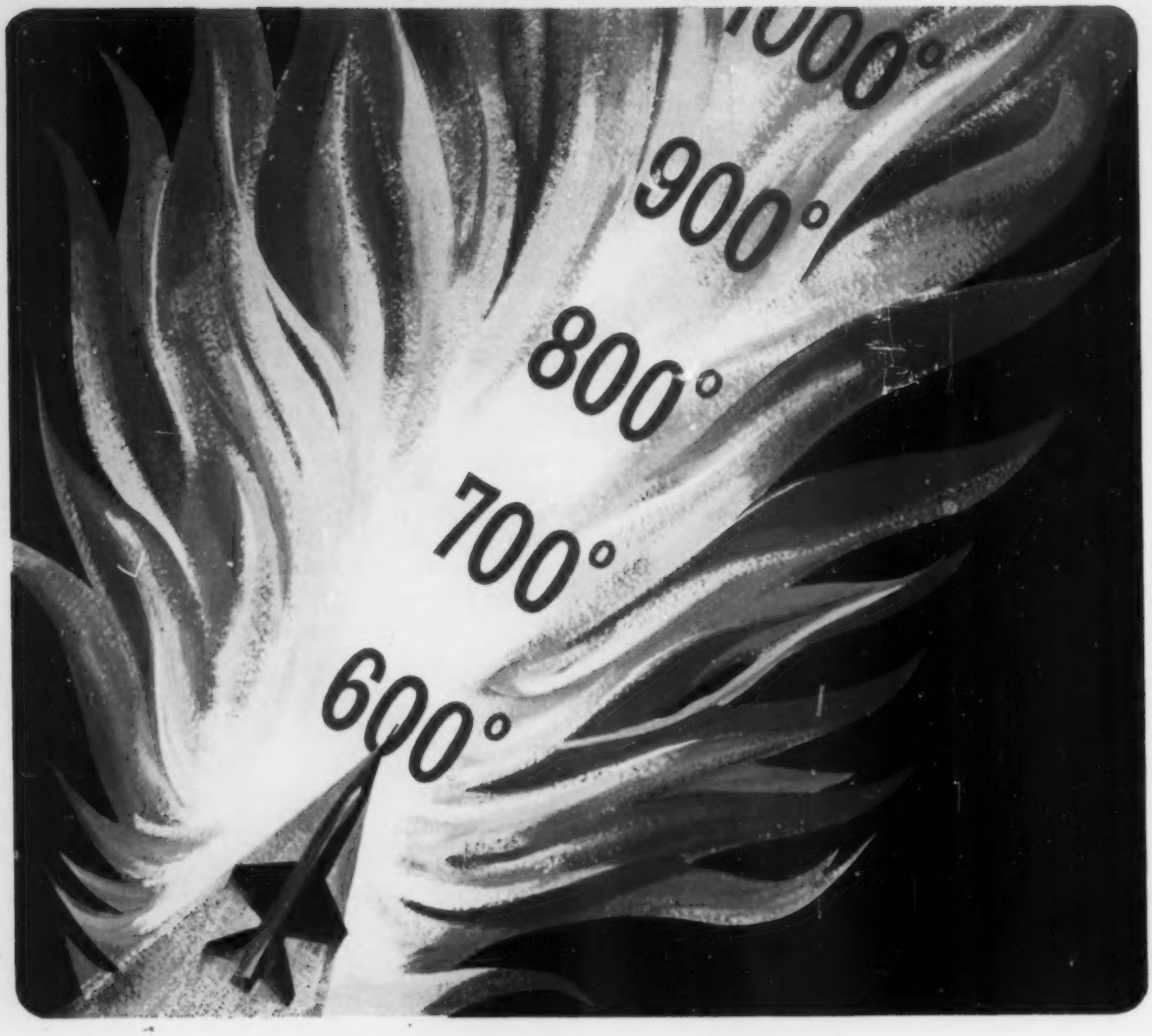
PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

Experience—*the added alloy in* **Allegheny Stainless**



Easy-to-form metals with high strength up to 1000 F

AM 350 and AM 355, precipitation hardening stainless steels by Allegheny Ludlum have many advantages for designers of missiles and supersonic aircraft in solving space age problems.

Among their many desirable properties, AM 350 and AM 355 combine high hardness and strength and stability up to 1000 F and yet possess good ductility. They are easy to form in the annealed condition.

They can be spun, drawn, formed, machined and brazed or welded using normal stainless steel procedures.

Both steels have excellent corrosion resistance and good resistance to stress corrosion and oxidation at higher strength levels.

AM 350 is available commercially in sheet, strip, foil, small bars and wire. AM 355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars, wire, sheet and strip.

For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355." **Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.**

ALLEGHENY LUDLUM

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

Some Ideas

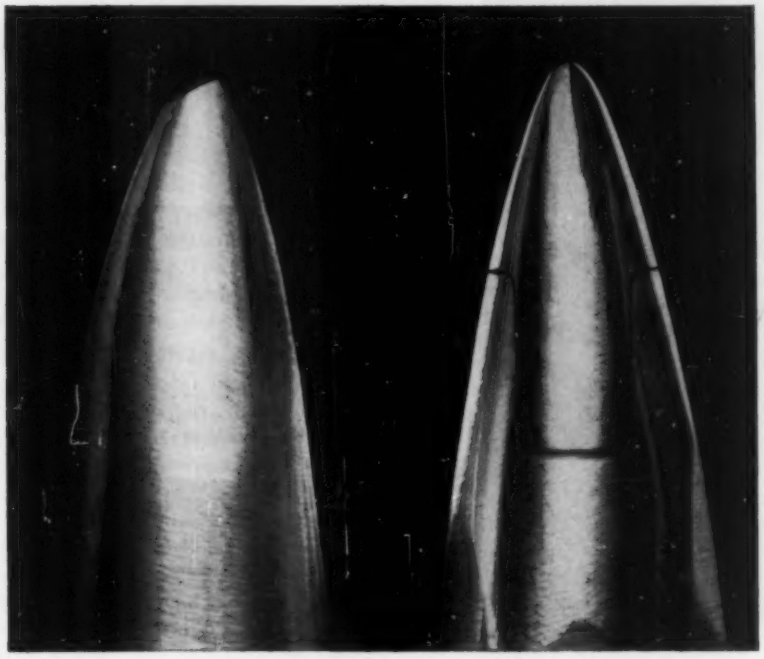
for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

It seems that today's rugged drafting films, such as K&E Herculene and Stabilene, can dish out punishment as well as take it. Smooth and comfortable as they are to work with, these films can blunt the points of some ruling pens after about 80 hours of drafting – though their effect on pencils is no more abrasive than any other material. For pen-and-ink work on Mylar-based films, K&E offers a simple solution . . .

Tough Pens for Tough-Toothed Films

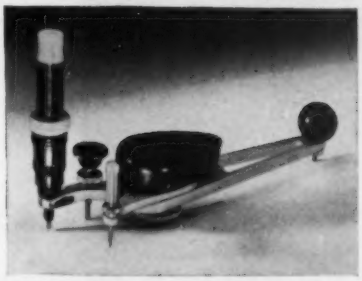
Two new K&E drawing instruments – the Paragon® Drop Bow Pen No. 813H and the Paragon Bow Pen No. 816H – are now part of the well-known Paragon *Red Tip* line. Both are pointed with Carboloy, hardest of metals. The Carboloy insert, butt-welded to the pen's blades, forms a tip that resists the subtly abrasive film, keeps its shape for hundreds of hours of neat, sharp, almost effortless inking.



Wearing power of new Carboloy-tipped K&E ruling pens was dramatically proved in a recent test series by a governmental agency. Results of our own tests are shown above. At left: plain steel tip after tracing 500 feet on Mylar®-based Herculene® Film. At right: Carboloy point of Paragon *Red Tip* pen after 5,000 feet – about a year's work – on the same material. If you'd like to see a more detailed report, we'll gladly send it to you, on request.

Days Between Refills

You can letter continuously – for remarkably long periods – without refilling the new Leroy® Reservoir Pen by K&E. Its



airtight cartridge – made of non-porous, transparent plastic – holds a liberal supply of your favorite waterproof India drawing ink. This pen is self-cleaning – fitted with a tiny weighted needle in the feed tube. If the pen has been idle for an hour or so, simply shake it lightly and vertically to actuate the needle, break up and remove any particles which may have settled in the passage. Smooth ink flow resumes immediately. You'll find the needle's efficient mechanical cleansing action helpful when washing the pen, too.

The Leroy Reservoir Pen (No. 3230) comes in seven sizes, 00 to 5. The points are specially designed for vertical use: when held in Leroy Scribers, these pens glide easily over paper or film surfaces, produce sharp, crisp, uniform lettering that reproduces beautifully. Leroy Reservoir Pens are available individually or in sets of seven (No. 3230S). A new K&E brochure gives full details. Ask us for it, today.

Easing A Sticky Situation

Do you sometimes have a tack-up problem where sticky adhesives don't do the job? Then maybe you need a good thumbtack (almost a forgotten item in the draftsman's kit). But K&E still has thumbtacks, and they are the best you can buy. They're made of nickel-plated steel, and have thin, streamlined heads that permit drafting machines to slide easily over them.

From thumbtacks to lumber crayons, there are a thousand and one other items almost forgotten, perhaps, but which K&E carries to serve every draftsman's need – as infrequent as that need may be.

Your nearby K&E dealer will be pleased to demonstrate these helpful drafting room items. Stop in and see him, or clip and mail the coupon below for more information.

Herculene, Stabilene, Paragon and Leroy are registered trademarks of Keuffel & Esser Co.

KEUFFEL & ESSER CO., Dept. PE-12, Hoboken, N. J.

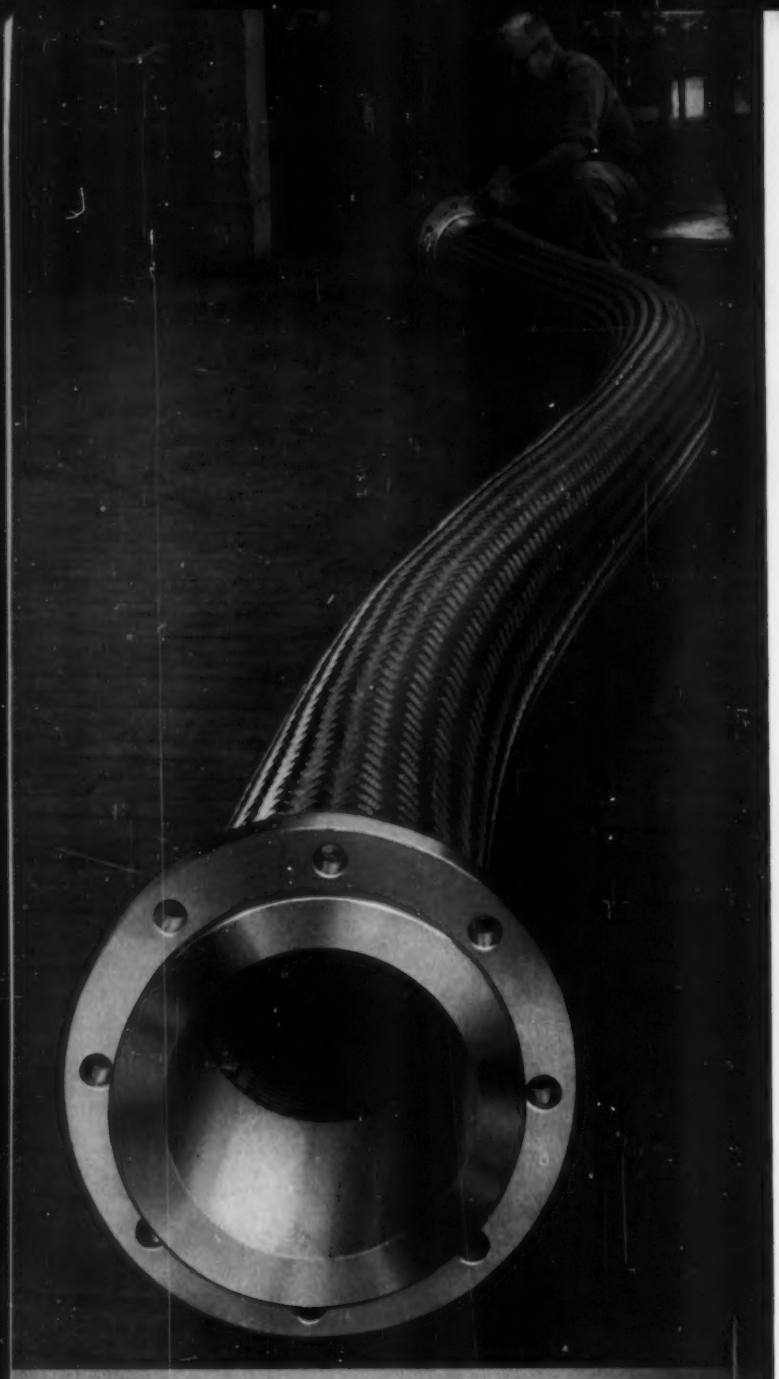
I'd like to know more about:

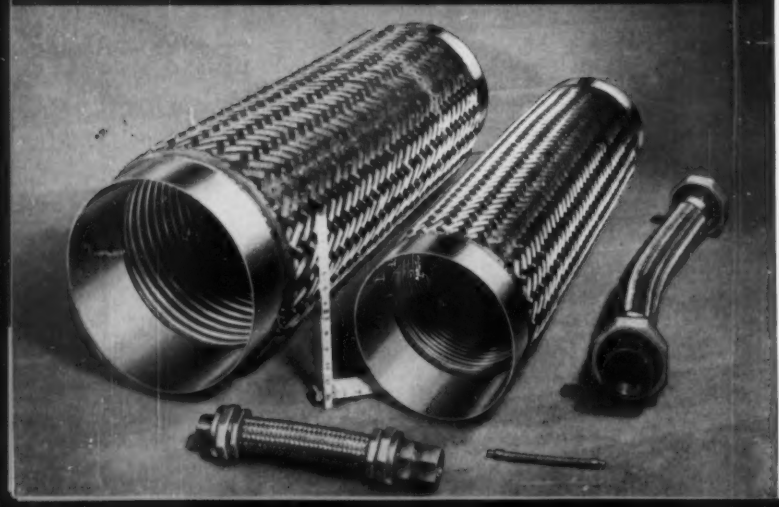
- ☐ New K&E Paragon Ruling Pens with long-wearing Carboloy tips.
- ☐ New K&E Leroy Reservoir Pen.

Name & Title_____

Company & Address_____

_____ 2003





BIG OR SMALL

FLEXIBLE TUBING ANSWERS TO TOUGH PROBLEMS

The flexible metal tubing assemblies on this page give an indication of the scope of facilities at Anaconda Metal Hose for designing and manufacturing tubing answers to tough problems.

The big 16½-foot, 8-inch diameter tube in stainless steel at the left was built for handling liquid oxygen in missile ground handling equipment. In the photo below, left rear, are two stainless steel connector assemblies—14-inch and 10-inch I.D.—also used in handling liquid oxygen.

From such assemblies down to the tiny ⅛-inch I.D. Vibration Eliminator shown in the foreground at the bottom of the page, the variety of flexible hose assemblies—in size, material, and design—is almost infinite.

FREE TECHNICAL SERVICE. Anaconda Metal Hose specialists are constantly working with design engineers on special flexible connectors and hose to meet new problems. Having broad experience working in stainless steel, other steel alloys, Monel, copper alloys, aluminum, and Teflon,* they can save you considerable time and money in designing the flexible connector best suited for your needs.

Our specialists are available to you through Anaconda Metal Hose representatives in leading cities – see listing "Metal Hose" in the Yellow Pages. Or write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. *Registered trademark for Du Pont fluorocarbon resins.

59136

ANACONDA®
METAL HOSE

ANNOUNCING A NEW OXIDATION RESISTANT

GRAPHITAR®

(CARBON-GRAPHITE)

FOR HIGH TEMPERATURE APPLICATIONS

Culminating five years of intensive research, engineers of The United States Graphite Company have developed a new oxidation resistant GRAPHITAR. In exhaustive tests, GRAPHITAR parts were exposed in an oxidizing atmosphere (air) at 1200 degrees F and after 200 hours, the GRAPHITAR showed a weight loss of less than six percent!

GRAPHITAR, which is available in many grades, is a versatile engineering material with unusual and outstanding properties that make it ideal for tough applications. It is non-metallic, resists chemical attack, has self-lubricating properties and a low coefficient of friction. It is mechanically strong, lighter than magnesium and is the perfect material for packing rings, pressure joint seals, clutch release bearings, fluid coupling seals, piston rings, pump liners and vanes.

For more information on this new oxidation resistant GRAPHITAR and its applications, write the GRAPHITAR product manager on your company letterhead.

R-279-1

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

←CIRCLE 36 ON READER SERVICE CARD

CIRCLE 37 ON READER SERVICE CARD 37

Aeroquip's Extensive Product Lines Fluid Piping

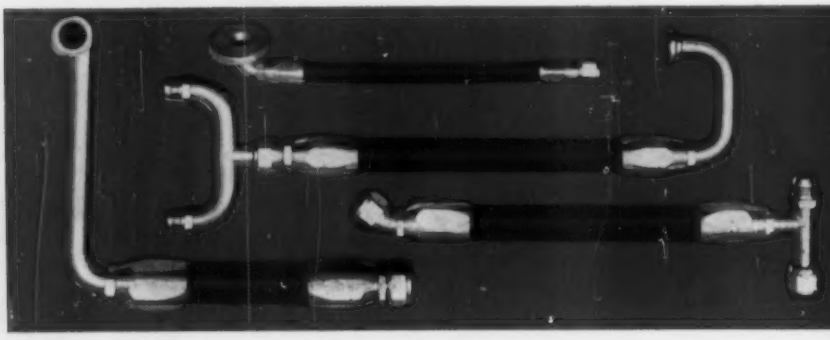
Highly qualified Aeroquip Sales Engineers are on call to furnish design assistance right in your engineering department. They follow through to assist at other stages of manufacture where Aeroquip's unmatched fluid line experience can also help you.

Aeroquip Field Engineers work with your engineers in building prototypes, assisting in fluid system test and modification.

Skilled Aeroquip Sales Engineers assist in various production planning functions, make time-saving and money-saving recommendations.

Aeroquip Service Engineers are trained troubleshooters who can analyze fluid systems under field conditions to verify system performance.

Experienced Aeroquip personnel work closely with your parts or service people to develop a service parts program to your exact requirements.



UNLIMITED RANGE OF AEROQUIP FLUID PIPING ASSEMBLIES

Fluid piping assemblies like these can decrease the number of components required, producing highly simplified and trouble-free fluid systems on your equipment.

And Facilities Provide Complete Service For Equipment Manufacturers

- DESIGN
- PROTOTYPE
- PRODUCTION
- FIELD SERVICE
- SERVICE PARTS

Aeroquip's unequaled experience in solving fluid piping problems has helped many equipment manufacturers save time and money. This experience is presented to you as the Aeroquip Fluid Piping Service. This unique service is available to any qualified equipment manufacturer desiring assistance in any and all phases of design, development or manufacture, as listed above.

Highly skilled Aeroquip sales and service engineers are available to work with you, in your plant or in the field. Backed by the most complete line of fluid piping products and extensive engineering and manufacturing facilities, these specialists can help you solve any fluid line problem. In many cases, solving the problem results in simplification of a fluid system or fluid systems to a point where fewer component parts are required. This can cut material costs, reduce ordering, stocking and processing requirements.

If you would like more information on the Aeroquip Fluid Piping Service, please write to us.

Write Today for Your Copy of Bulletin 614 Describing the Benefits of the Aeroquip Fluid Piping Service.

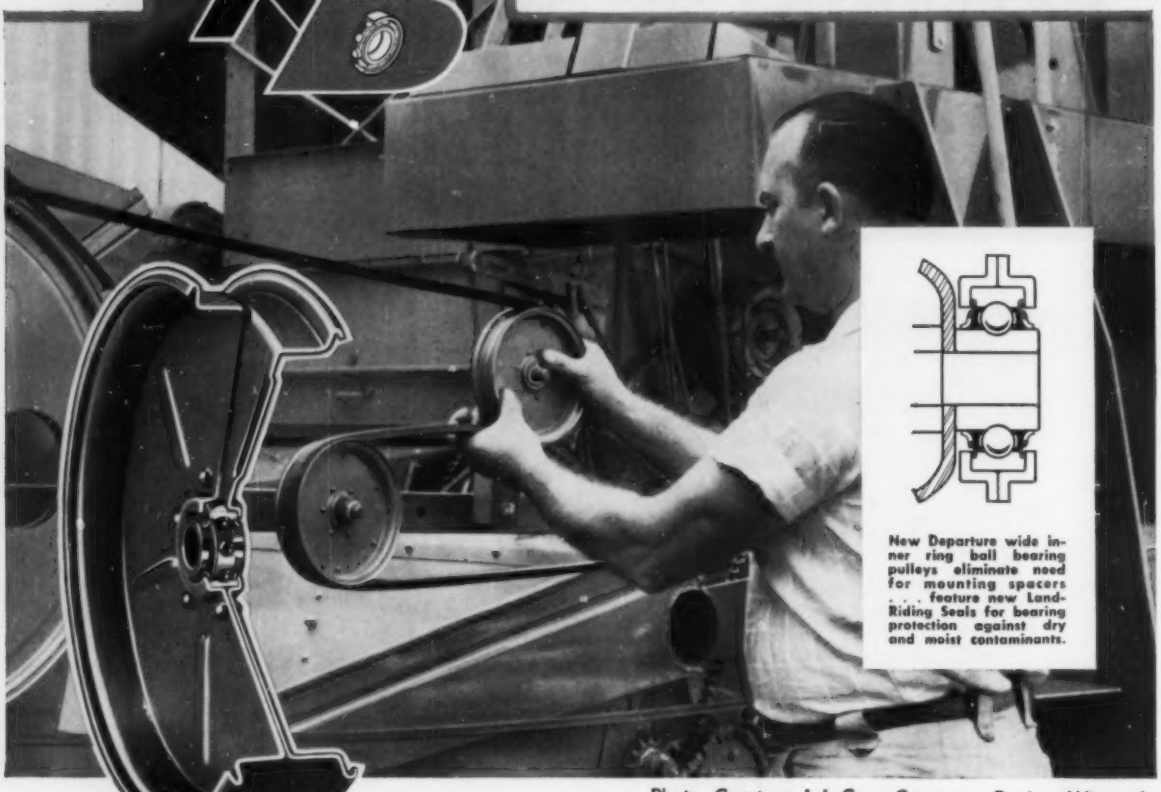
Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

CIRCLE 39 ON READER SERVICE CARD

CASE HISTORIES



New Departure wide inner ring ball bearing pulleys eliminate need for mounting spacers . . . feature new Land-Riding Seals for bearing protection against dry and moist contaminants.

Photo: Courtesy J. I. Case Company, Racine, Wisconsin

Idler Pulley Assemblies Help Combine Manufacturer Cut Inventory & Assembly Costs!

CUSTOMER PROBLEM:
Leading farm implement manufacturer experiencing rising costs in the installation of ball bearing pulleys on combines and other farm implements.

SOLUTION:
N/D Sales Engineer, in cooperation with the manufacturer, made an evaluation of pulley applications. He then recommended N/D Land-Riding Seal pulley assemblies containing ball bearings with *wide* inner rings. The wide inner ring paved the way to cutting costs by eliminating conventional spacer inventories. Moreover, the manufacturer now enjoys additional savings because N/D Lubricated-for-Life ball bearing pulleys are *fully assembled* at delivery . . . simplifying inventory even more!

The wide inner ring bearing, butt mounted rigidly against face plate, requires a minimum of parts handling and adjusting at assembly. In addition, these 8" O.D. pulleys have rolled sheave edges for belt protection. All pulleys come with the new and exclusive N/D Land-Riding Seals, factory greased, ready to offer full maintenance-free protection against dry and moist contaminants.

If *you're* a user of flat and "B" section V-Belt pulleys, sizes from 2¾" to 8" O.D., why not check on the savings N/D has to offer? Contact your local N/D Sales Engineer or, write today for the new N/D Idler Pulley Bulletin giving complete specifications and mounting data. New Departure Division, General Motors Corp., Bristol, Conn.

Replacement pulleys available through United Motors System and its Authorized Bearing Distributors.

NEW DEPARTURE
BALL BEARINGS
proved reliability you can build around

Product Engineering

HORIZONS

December 21, 1959

Christmas, 1959

In a country and a technological civilization which stress change, even annual change, it is paradoxical that the holiday season should remain. Further, despite the commercialization of Yuletide, the debunking of tradition and folklore, the over-sophistication and the superficiality of our day, the spirit that is Christmas still survives—is, if anything, growing stronger year by year.

This can be dismissed easily as another evidence of our over-sentimentality, even as a return to childhood, but it isn't either. It is more nearly an annual expression of the faith and hope of our world for a better tomorrow. We feel impelled at this time of the year to express this faith in religious rather than scientific terms. This implies to many people basic antipathy between science and religion, but many scientists do not agree.

We were struck by the recent reflections (in his speech at Cooper Union) of Dr Harold Urey, Nobel prizewinner: "In religion, most scientists are skeptics, that is, they do not subscribe to the dogmas of Christianity, Judaism or any other religion. They mostly regard the supernatural aspects of these religions in the same light as they do those of the religions of ancient Egypt, Greece and Rome . . . On the moral side, they (the scientists) are mostly close followers of the precepts of Christianity and Judaism.

"Science is not a substitute for religion. It very often imposes a condition represented by the word 'must.' We cannot do things which do not conform to the requirements of natural laws and facts. But science never imposes a condition represented by the word 'ought.' There is no requirement imposed by science that certain types of human behavior are morally right and others are morally wrong. Scientists live by the morals taught to them directly or indirectly by the great religions practiced in the countries where they reside.

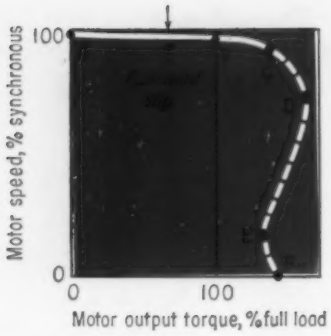
"Science gives us no purpose in living beyond having a pleasant existence in one way or another. Scientists themselves are inspired by the magnificent things which they study. But science does not give the ordinary man, whose daily life is often drab and anything but sublime, any motive that gives him a feeling of dignity. Such feelings are so necessary if he is to rise above the disappointments and temptations of life and if he is to do the best of which he is capable. One of the great needs of this age is a great interpretation which can accept the facts of science and at the same time can give inspiration to fill this great void. I do not believe that current evangelists . . . have made any contribution to solving this fundamental problem."

Perhaps in this skeptic's lament lie some of the reasons for our domestic problems, our juvenile delinquency, our world unrest. As educational levels rise all over the world, as our knowledge of this world and the worlds beyond grows by leaps and bounds, we need again to be reminded of man's greatest basic need—a moral standard by which he can live. And yet that standard has been there through all historical time, and within all religions.

It is simple and straightforward. Christians call it the Golden Rule: **Do unto others as ye would have them do unto you.**

May this be our Christmas wish to you.

These speed-torque curves for speedier . . .



PREDICTION OF INDUCTION-MOTOR PERFORMANCE

Every fifth motor in the 1-to-250 hp range must handle loads not described in motor catalogs . . . and that means you've got to start figuring. Here are pre-calculated curves that cut down the math needed. Author shows shortcuts for obtaining such curves and graphical methods for using them in acceleration computations.

CHARLES C LIBBY, *Electrical Div, Fairbanks, Morse & Co, Freeport, Ill*

It's easy enough to choose nowadays among most polyphase induction motors in the integral-hp class. Four out of five can be selected by just matching the motor to a well-defined load. It's the other 20%—for not-so-standard applications—that take most design time and ingenuity. They require careful study of the duty cycle—acceleration, starts and stops, load changes. An important tool in all such studies is the well-known speed-torque curve shown above. Here are new shortcut techniques to make that tool more effective.

Curve Matching

The time it takes to accelerate a motor—dependent on its speed and torque characteristics from zero to synchronous speed—can now be estimated in a single calculation. It is done by first visually matching the shape of the new motor's speed-torque curve with one of the pre-calculated typical curves charted on the next page. The value of D on the typical curve is then substituted into either of these two simplified versions of the basic motor-acceleration equation.

$$t_{AT} = D\,\frac{(WR^2)_T\left(\frac{RPM_S}{1000}\right)^2(1-S)}{1.62HP}$$

$$= D\,\frac{KE_T(1-S)}{275HP}$$

The curves on the chart and for a new motor are plots of accelerating torque only—the friction and work-load torques are subtracted from motor-output torque beforehand. All torque and speed values are in percent. Therefore the curves are general and apply to polyphase squirrelcage motors of any rating, inertia (including load), and speed, provided the curves match. However, the method is not applicable to motors whose speed-torque curves are affected by variables such as the centrifugal switch in a single-phase motor, external resistance in a slip-ring motor, variable control in a dc motor. The method will work with synchronous motors if they are started on full voltage. For any motor, accuracy of the method will depend on accuracy of the new speed-torque curve available for that motor—usually a tolerance of ±5%.

The method is simple: If a new curve matches one of the typical curves exactly, then the D value can be read directly from the chart. Or if it lies parallel to and between two typical curves, interpolate for D. But if the new curve does not resemble any of the typical curves—the case when reduced-voltage starting or other special conditions exist—then new typical curves should be calculated by the conventional summation process indicated in this basic acceleration equation:

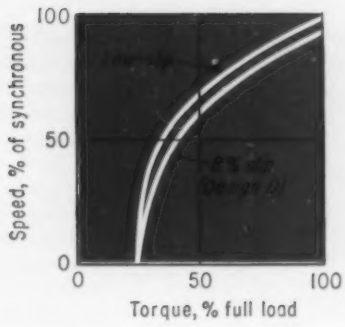
$$t_{AT} = \frac{(WR^2)_T(RPM_S)}{308T} \times \left[\frac{\text{incremental speed change, \%}}{\text{avg accel. torque, \%, during increment}}\right]_{\text{zero speed}}^{RPM_F}$$

The bracketed portion of the basic equation is simply a summation of all the speed intervals from zero to full-load speed. Suggested speed intervals are: zero to $\frac{1}{3}$; $\frac{1}{3}$ to $\frac{2}{3}$; $\frac{2}{3}$ to $\frac{5}{6}$; $\frac{5}{6}$ to 0.92; and 0.92 to full-load speed. For high-slip motors, one or more higher speed intervals can be eliminated, ending each time with full-load speed. The summation has a separate value—designated D on the chart—for each curve shape.

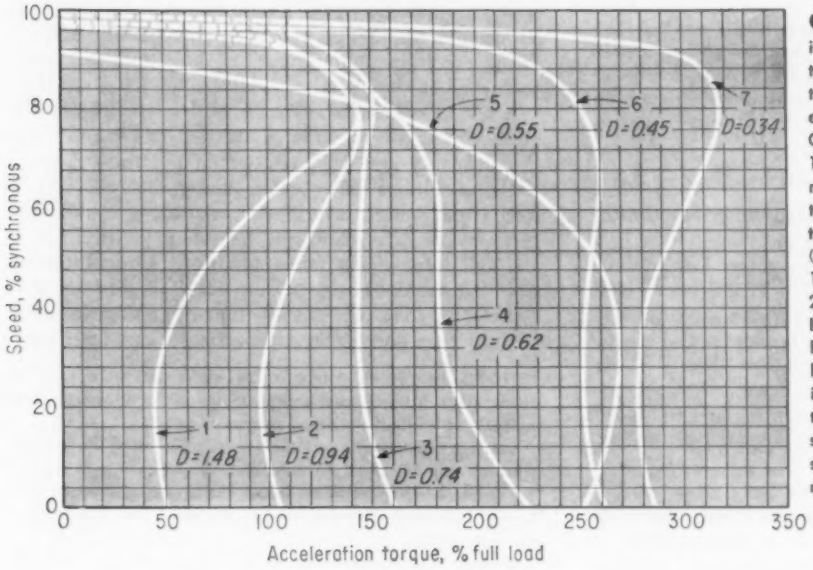
To Plot Speed vs Torque

Although most motor manufacturers will provide the speed-torque curves needed for motor evaluations such as curve-matching, it is not always convenient or necessary for the user to request them. Instead of such complete

Speed-torque curve . . . here is hypothetical, but helps define NEMA terms. Letters indicate points of important torque measurement: *A*—no load; *B*—full load (rated); *C*—max for short time; *D*—max pullout; *E*—min accelerating (friction and work-load torques will reduce this value); *F*—starting (locked rotor). Dotted portion of curve is applicable to initial acceleration only. All values assume full rated voltage and frequency at terminals.



Combined friction and work . . . torque for each of these typical induction motors (starting under load) is 25% at zero speed, 100% at running speed, and varies as square of speed for intermediate values.



Curve-matching method . . . is based on these typical speed-torque curves for which acceleration constant *D* (see accompanying equations) has been pre-calculated. Curves 1 through 6 are based on 1800-rpm polyphase squirrelcage motors starting on full voltage with the "typical" friction and work torques shown in chart above (NEMA standard MG 14.01). Curve 1—NEMA Design B, 250-500 hp; 2—Design B, 150 hp; 3—Design B, 30-50 hp; 4—Design C, 30-50 hp; 5—Design D, 8% slip, 30-50 hp; 6—Design B, 1-3 hp. Curve 7 is same as 6, except that zero friction and work torques are assumed. Curves also apply to other speeds and loads—see example on next page.

data, approximations will often do the trick, and save a lot of time and effort.

Nameplate Data and published information based on NEMA (National Electrical Manufacturers Association) standards are guaranteed within certain limits. A reasonably accurate speed-torque curve can be drawn from such data–zero-speed torque, max torque (80% speed for design A, B and C), and rated-speed torques are frequently given–but there are these limitations:

- Torque and efficiency claims are conservative. Actual motor might perform differently, even though better.
- Voltage is assumed to be exactly at rated value. Variations in performance with voltage are indicated in voltage-deviation graph.
- Line frequency is assumed constant.
- Ambient temperature is assumed 77 F, with rated rise in the motor.

Efficiencies are normally available from the manufacturer for ½, ¾ and full load points. When only full-load efficiency is given, assume that it remains constant from 75 to 125% load . . . error will be less than ±5%.

Slip at full load (designated *S*) is guaranteed within ±20%. It can be calculated from full-load rpm given on the nameplate. An implied slip of $S = 0.05$, which is 5% of synchronous speed, will actually be somewhere between 0.04 and 0.06.

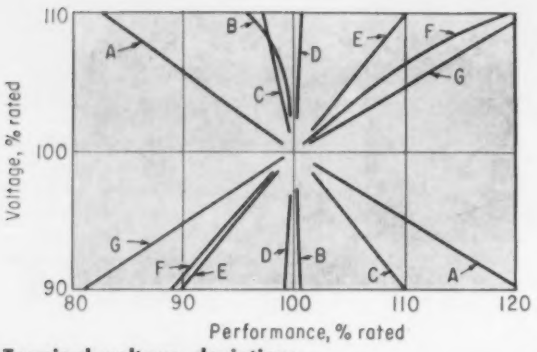
Test the Driven Load

Determination of driven-load characteristics–important to motor selection–need not involve elaborate test equipment; adequate answers in most instances are obtained with these compromises:

(CONTINUED NEXT PAGE)

SYMBOLS

t_{TA} = total accelerating time, sec (to nearly full-load speed)
$(WR^2)_T$ = total inertia of motor and load, lb-ft² (referred to motor-shaft speed)
KE_T = total kinetic energy of motor and load, ft-lb (at synchronous speed)
RPM_F = motor full-load speed, rpm
RPM_S = motor synchronous speed, rpm
T = motor full-load torque, lb-ft
HP = motor rating, hp
S = motor full-load slip, fraction of RPM_S
D = constant for curve shape in equations



Terminal voltage deviations . . . greatly affect performance of induction motors. A—full-load slip (decreases when voltage increases); B—full-load power factor; C—full-load current (decreases slightly with increase in voltage); D—full-load efficiency; E—locked-rotor current; F—no-load current; G—starting and max torques (vary as square of applied voltage).

Breakaway torque of the driven load can be found without using a motor. Simply apply a measurable force to a lever arm attached to the load-input shaft. Locked-rotor torque of a motor selected for a load should exceed load breakaway torque by 25 to 100% for safe margin.

Starting torque of the load after breakaway also can be measured with a lever—by rotating the load slowly (about 1 rpm). The measured value, subtracted from motor torque, gives accelerating torque. Starting and full-speed torques are equal for constant-torque loads such as friction or lifting.

If a motor—preferably similar to the desired type—is available to drive the load, **the nameplate data plus readings of input current will help give a fair estimation of power needed by the load.** For rated voltage and frequency, current is proportional to load.

Motor slip—measured on an actual motor driving the load—also gives a fairly accurate indication of the load's requirements. Slip is directly proportional to load from 10 to 110% load. But very accurate speed measurement is essential—1% speed error results in 30% load error for a typical NEMA Design B induction motor. Revolution counters should be used if load and speed can be held constant long enough. The full-load slip must be known accurately, or the method is of little value; also, voltage, frequency and temperature rise must be at rated value for each point in the test.

Motor temperature rise also indicates the amount of load being driven. At zero load, rise might be ½ to ¾ full-load rise. At higher loads, rise increases with load. Some nonlinearity is introduced, particularly at loads below 50%, because of reduced efficiency and power factor. Stabilization of temperature must be achieved before taking each reading. Here's a tip for taking approximate temperature readings on horizontal open motors: Remove lifting eye from motor frame, fill hole with oil, insert thermometer.

A test motor can be calibrated with a dynamometer at given conditions of terminal voltage, temperature and line frequency, and will give accurate indication of power if the conditions are repeated during the test. Uncalibrated test motors have limited accuracy—the published performance data are usually minimum values for ½, ¾ and full load, giving false indications of performance. Any test motor should be run near full load for best accuracy. A 25% overload is acceptable, and gives better accuracy than that for an over-size motor carrying ½ load.

EDITOR'S NOTE: Mr. Libby is the author of these previous articles that give comprehensive details on several important methods of evaluating motor performance:

Let the Load Be Your Guide When Selecting Polyphase Motors, Aug 18 '58, p 84, describes all types of loads, including those requiring constant speed and speeds that drop with load. It has comprehensive charts and tables that help choose the right motor.

Controlling Temperature Rise in Squirrelcage Induction Motors, Jan '57, p 167, explains all the standards and calculating methods prerequisite to evaluating any motor and its insulation, and gives equations, charts and tables that help when changes are necessary in duty cycle or enclosure.

Lower-speed Motors for High-performance Drives, Sept 16 '57, p 96, compares the very different effects of kinetic energy vs inertia on motor performance.

Driving High-inertia Loads, Apr '56, p 142, relates flywheel inertia to motor design, gives equations and examples.

These other basic articles, by other authors, provide additional background for calculating duty cycles:

Significance of WK² and How to Calculate It, Mid-Oct '53, p H-24, is a thorough mathematical study of motor inertia, giving all important derivations, nomographs, tabulations of typical part-shapes, densities—also has examples showing how to determine inertia of system, and pick motor to drive it.

Determination of Motor Hp from Duty Cycle, (Part I), Aug '50, p 131, describes several methods of calculating equivalent hp, gives examples. Part II, Sep '50, p 135, goes into plug-starts and plug-stops.

Matching the Curves—an Example

Determine accelerating time, zero to nearly full-load speed, for a 20-hp, 1200-rpm, 3%-slip squirrelcage motor driving a load whose total inertia (including motor rotor) is 100 lb-ft². The total friction and work torque of the load and motor is assumed equivalent to the low-slip curve on the friction and work-load graph. To solve:

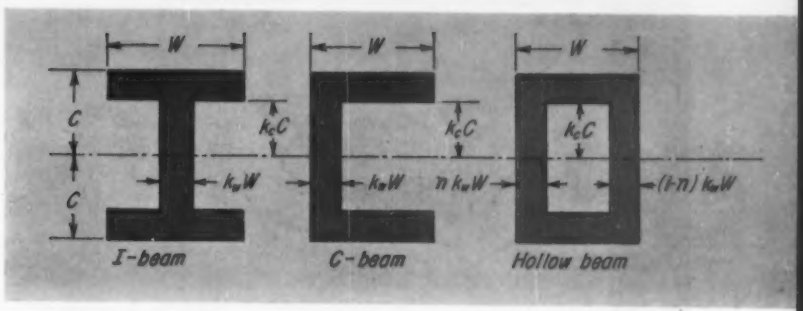
(a) Determine actual accelerating torque by subtracting friction and work torque from total torque output of motor. For this example, assume that the resultant curve shape resembles curve 3 on the curve-matching graph.

(b) Read value of $D = 0.74$ and substitute into appropriate acceleration equation:

$$t_{AT} = 0.74 \frac{100 \left(\frac{1200}{1000} \right) (1 - 0.03)}{1.62 \times 20}$$

$$= 3.2 \text{ sec}$$

NEW BOOK COMING . . . Mr Libby's comprehensive new book *Motor Selection and Application*, scheduled for publication next month by McGraw-Hill, will contain all of the material in this and his previous articles, as well as a thorough discussion of motor theory.

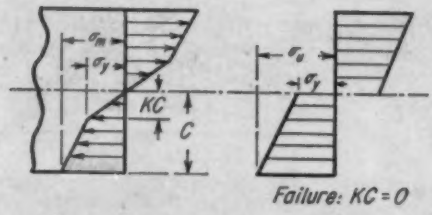


more help on tapping the

RESERVE STRENGTH IN METAL PARTS

"How far can you exceed the yield strength of a material, and get away with it?"—that theme of an earlier article by this author is carried further here with his new design curves for three additional types of beam sections under pure bending loads. Two sample problems also show how to find the exact load that causes fracture.

DOMINIC J GRAZIANO
Mechanical-design consultant
Hawthorne, N J



THE AUTHOR'S METHOD

When a beam is bent beyond a certain point, its outer fibers yield first; increasing the load causes more fibers to yield. The extent of yielding in the section can be determined by employing a dimensionless factor K which, when multiplied by C, the distance from neutral axis to extreme fibers, gives the distance to point where yield begins to occur. Distance KC is the unyielded section; when the ultimate strength of the material is reached, KC equals zero and the structure fails. A rule of thumb is to stay within a stress limit at which no more than 50% of the cross-section will take a permanent set.

Knowing the ultimate strength, σ_u, and yield strength, σ_y, of the material, and the applied moment or load, factor K can quickly give the percent cross-section that will yield (assuming the beam is overloaded), the resulting permanent deformation to the beam, and the true load that will cause failure.

Some permanent set is the price you pay when you must design past the yield strength of a structural or machine part. But the real difficulty is that standard stress-deflection equations do not hold true in this "plastic" region of stress. They do not even give a true answer to the common problem: What load will cause fracture?

Though special equations for the plastic region are complex, there are new design curves that reduce computation time. A previous article by the author, "Tap the Reserve Strength in Metal Parts," Sep 29, '58, gave such curves for rectangular, circular, tubular and diamond sections under pure bending loads. The same method is also useful for I-beam, C-beam and hollow-rectangular sections. Equations for these sections were published in the previous article, but were acknowledged as too unwieldy for practical use.

Because of the wide range of possible variations in dimensions for I-, C- and hollow beams, a computer program was set up to develop data for curve plotting. Sections of the three-types of beams are shown above. Over-all dimensions are defined by letters C and W. To reduce the number of variables, thicknesses of ribs and flanges are given as ratios of over-all dimensions by employing the ratio factors k_c and k_w. Even so, 91 families of curves were required. These were finally cut down to nine flange and web shapes. For a particular beam section, linear interpolation must be employed.

THE DESIGN CURVES

Nine families of curves, Figs 2 to 10, give the relationship between moment rations M/M_r and percent

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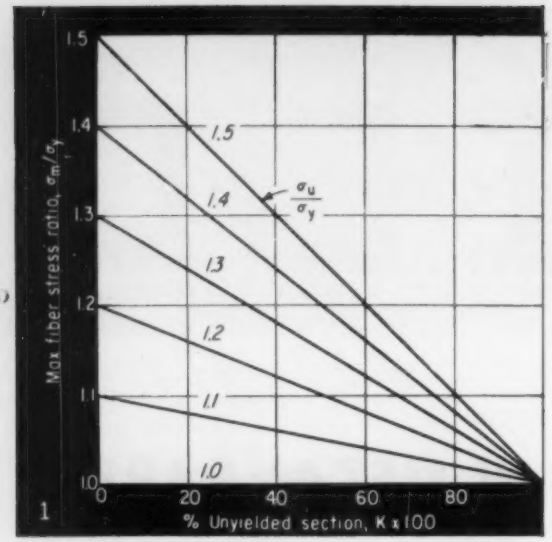


Fiber stress ratio . . . as influenced by unyielded depth for ratios of ultimate to yield stress

unyielded depth, K, for a complete range of k_c. The curves are only for values of $k_w = 0$, $k_w = 0.4$ and $k_w = 1$ (solid rectangular section)—but this limitation should not defeat normal interpolation procedures. Once K is known, curves in Fig 1 give the maximum fiber stress, which leads to a correct evaluation of the load that causes failure. Two problems below illustrate the method.

PROBLEM 1—SIMPLY-SUPPORTED BEAM

A simply supported beam is to support a 6200-lb load at its center. Beam section is solid rectangular, 2 in. high by 1.25 in. wide by 8 ft long. Material is steel with a yield stress of $\sigma_y = 138{,}500$ psi, and an ultimate stress of $\sigma_u = 180{,}000$ psi.

Determine:

(1) Percent of section depth that yields
(2) Maximum fiber stress
(3) Maximum allowable moment for the beam
(4) Load that will cause failure
(5) Margin of safety
(6) Permanent set

Bending moment at the center:

$$M = \frac{PL}{4} = \frac{6200(8)(12)}{4} = 149{,}000 \text{ in.-lb}$$

Section Modulus:

$$Z = \frac{I}{C} = \frac{2}{3} WC^2 = \frac{2}{3}(1.25)(1) = 0.833 \text{ in}^3$$

Yielding Moment:

$$M_y = \sigma_y Z = 138{,}500(0.833) = 115{,}500 \text{ in.-lb}$$

Stress Ratio:

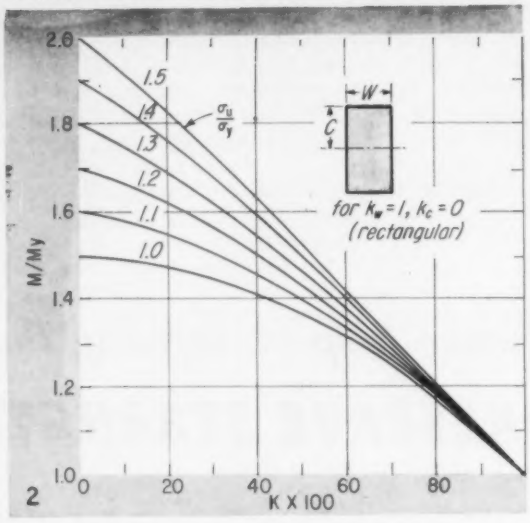
$$\frac{\sigma_u}{\sigma_y} = \frac{180{,}000}{138{,}500} = 1.3$$

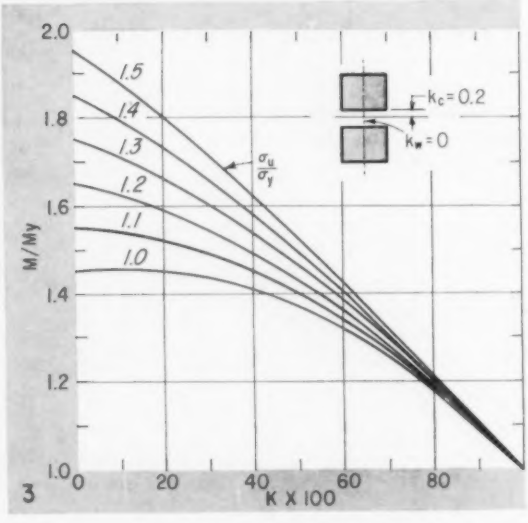
Moment Ratio:

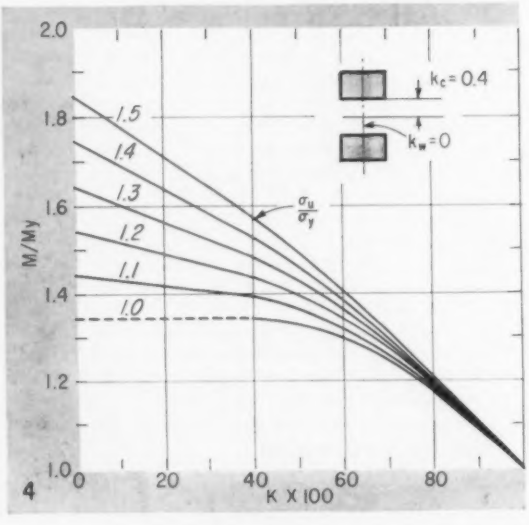
$$\frac{M}{M_y} = \frac{149{,}000}{115{,}500} = 1.29$$

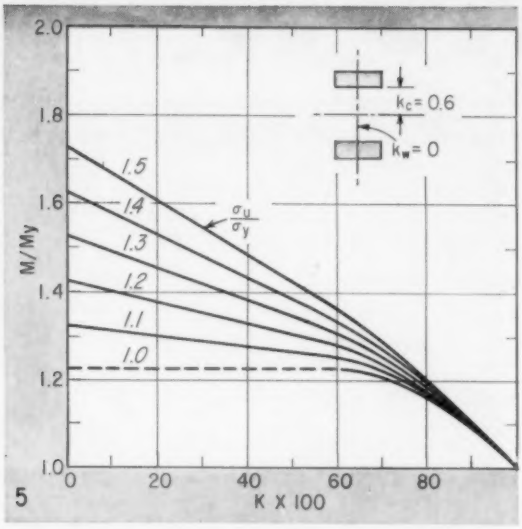
(CONTINUED ON PAGE 48)

(M/M_y = moment ratio; $K \times 100$ = % unyielded section





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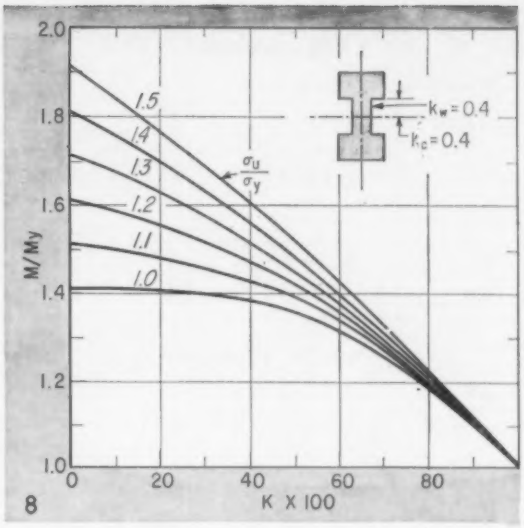
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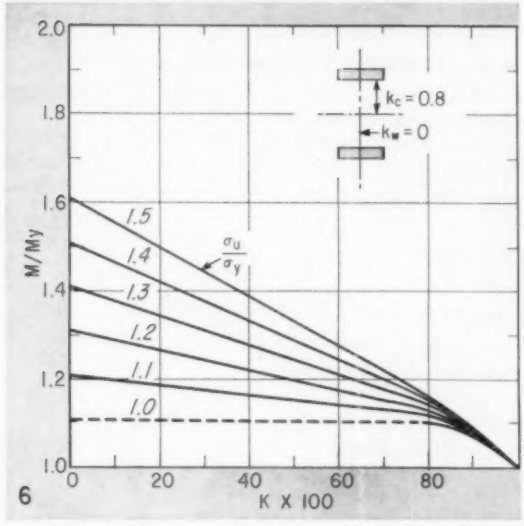
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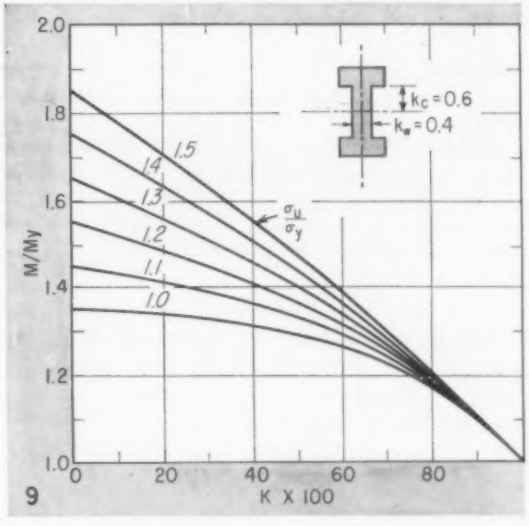
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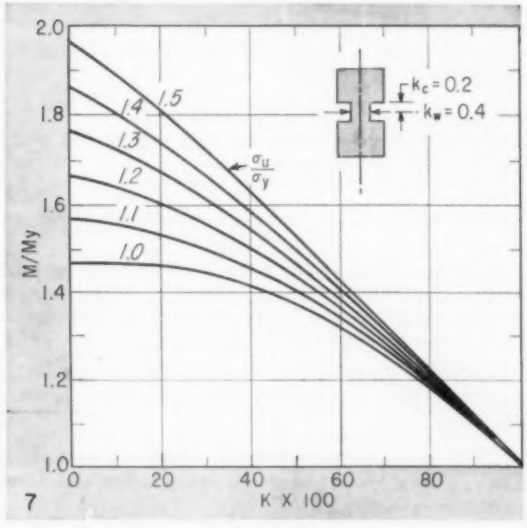
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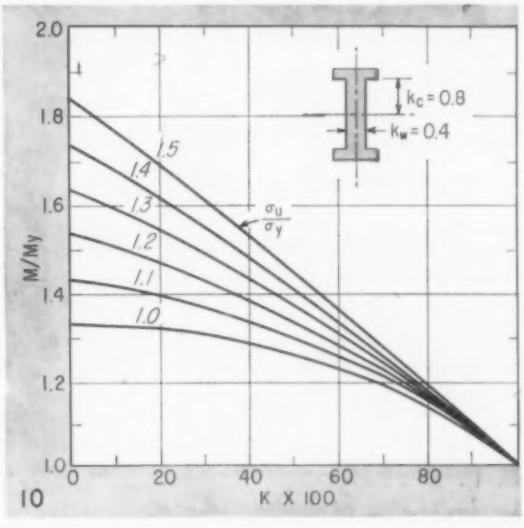
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Curves are derived from these equations

For the range: $0 \leq K \leq k_c$

$$\frac{M}{M_y} = R\left\{\frac{3}{2}[1 - k_c^3(1 - k_w)] - \frac{1}{2}k_w K^3 + \left(\frac{\sigma_u}{\sigma_y} - 1\right)\left[1 + k_c^3(1 - k_w)\left(\frac{3}{2}K - k_c\right) - \frac{3}{2}K\left(1 - \frac{k_w K^3}{3}\right)\right]\right\}$$

For the range: $k_c \leq K \leq 1$

$$\frac{M}{M_y} = R\left\{\frac{3}{2} - \frac{k_c^3}{K}(1 - k_w) - \frac{1}{2}K^3 + \left(\frac{\sigma_u}{\sigma_y} - 1\right)\left[1 - \frac{3}{2}K\left(1 - \frac{K^3}{3}\right)\right]\right\}$$

where

$$R = \frac{1}{1 - k_c^3(1 - k_w)}$$

From Fig 2 for $\sigma_u/\sigma_y = 1.3$ and $M/M_y = 1.29$, K is 70.5%.

Solutions:

(1) **Percent of section depth yielded** is: 100-70.5 = 29.5%.

(2) **Maximum fiber stress:** From Fig 1, for K = 70.5, $\sigma_m/\sigma_y = 1.09$; then $\sigma_m = 1.09$ (138,500) = 151,000 psi.

(3) **Max allowable moment** (causing fracture) is the value of M at K = 0 (where material has yielded completely). Returning to Fig 2, at K = 0 and $\sigma_u/\sigma_y = 1.3$, $M/M_y = 1.8$. Therefore

$$M_u = 1.8(115{,}500) = 208{,}000 \text{ in.-lb}$$

This calculation is of vital importance. Many engineers err too far on the safe side by using:

$$M_u = \sigma_u Z = (180{,}000)(0.833) = 150{,}000 \text{ in.-lb}$$

(4) **Load that will fracture the beam** is

$$P = \frac{4M_u}{L} = \frac{4(208{,}000)}{8(12)} = 8700 \text{ lb}$$

(5) **Margin of safety** is

$$(208{,}000)/(149{,}000) - 1 = 0.4$$

(6) **Equation for permanent set** δ for a simple beam is

$$\delta = \left(\frac{eL^2}{4C}\right)\left(\frac{1 - K}{K}\right)$$

where e = unit elongation (0.002 in./in.). Thus

$$\delta = \frac{(0.002)(8 \times 12)^2}{4}\left(\frac{1 - 0.705}{0.705}\right) = 2 \text{ in.}$$

PROBLEM 2—WITH I-BEAM SECTION

Repeat problem, using I-beam whose cross-section is 2 in. high, 1.25 in. wide; with 0.4-in. web and 0.5-in. flanges

$$k_w = 0.4/1.25 = 0.32; \qquad k_c = 0.5/1 = 0.5$$

$$R = \frac{1}{1 - (0.5)^3(1 - 0.32)} = 1.092$$

Because

$$R = \frac{Z \text{ (for rectangle)}}{Z \text{ (for actual section)}}$$

$$Z = \frac{Z \text{ (for rectangle)}}{R} = \frac{0.833}{1.092} = 0.763 \text{ in.}^3$$

$$M_y = Z\sigma_y = 0.763(138{,}500) = 106{,}000 \text{ in.-lb}$$

$$\frac{M}{M_y} = \frac{149{,}000}{106{,}000} = 1.41$$

The following interpolations are made from Figs 8, 9 and 2, for $M/M_y = 1.41$:

- Where $k_c = 0.4$, and $k_w = 0.4$, K = 0.550
- Where $k_c = 0.6$, and $k_w = 0.4$, K = 0.490
- From Fig 2, K = 0.57 at $k_w = 1$.

Solutions:

For $k_c = 0.5$, $k_w = 0.4$:

$$K_{avg} = \frac{0.550 + 0.490}{2} = 0.520$$

Therefore, by interpolation:

$$\frac{0.57 - 0.52}{0.6} = \frac{0.57 - K}{0.68}$$

From which K = 0.514. Correct value from equations is 0.516.

(1) **Percent of yielded depth** is 100-51.4 = 48.6%.

(2) **Max fiber stress** from Fig 2 is:

$$\sigma_m = 1.145(138{,}500) = 159{,}000 \text{ psi}$$

(3) **Max moment,** M_u/M_y, is obtained by the same interpolation procedures as above (at K = 0).

- From Fig 2, $M_u/M_y = 1.80$
- From Fig 8, $M_u/M_y = 1.71$
- From Fig 9, $M_u/M_y = 1.65$

For $k_c = 0.5$, $k_w = 0.4$:

$$\left(\frac{M_u}{M_y}\right)_{avg} = \frac{1.71 + 1.65}{2} = 1.68$$

As k_w decreases, M_u/M_y decreases, therefore,

$$\frac{1.8 - 1.68}{1 - 0.4} = \frac{1.8 - M_u/M_y}{1 - 0.32}$$

$$M_u/M_y = 1.664$$

Then $M_u = 1.664$ (106,000) = 176,500 in.-lb.

(4) **Fracturing load is**

$$P = \frac{4M_u}{L} = \frac{4(176{,}500)}{8(12)} = 7350 \text{ lb}$$

Other means of interpolation can be used, employing the figures for $k_w = 0$, in place of $k_w = 1$. In any case, linear interpolation gives sufficient accuracy within the range of these curves.

FOR REPRINT of above article, just check P-25 on one of the Reader Service cards bound in this issue.

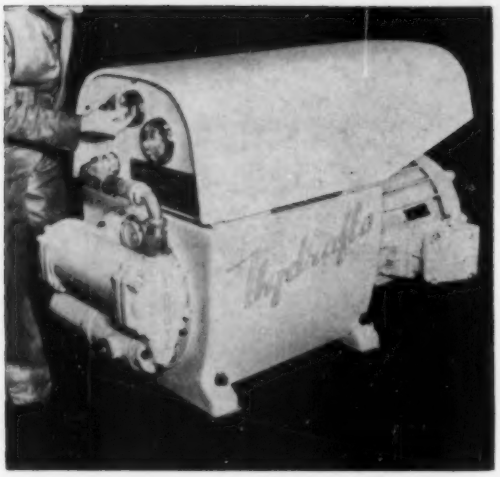
EDITOR'S NOTE: For the latest on stress-analysis techniques, see:

Acoustoelasticity, July 20, p 56—A new technique employs polarized high-frequency sound waves to analyze stresses (including residual stresses) in machine parts. For free reprint, specify E 94 on a Reader Service card.

PhotoStress Analysis, Mar 2, p 43—current applications of the PhotoStress technique for determining strains in structures under load.

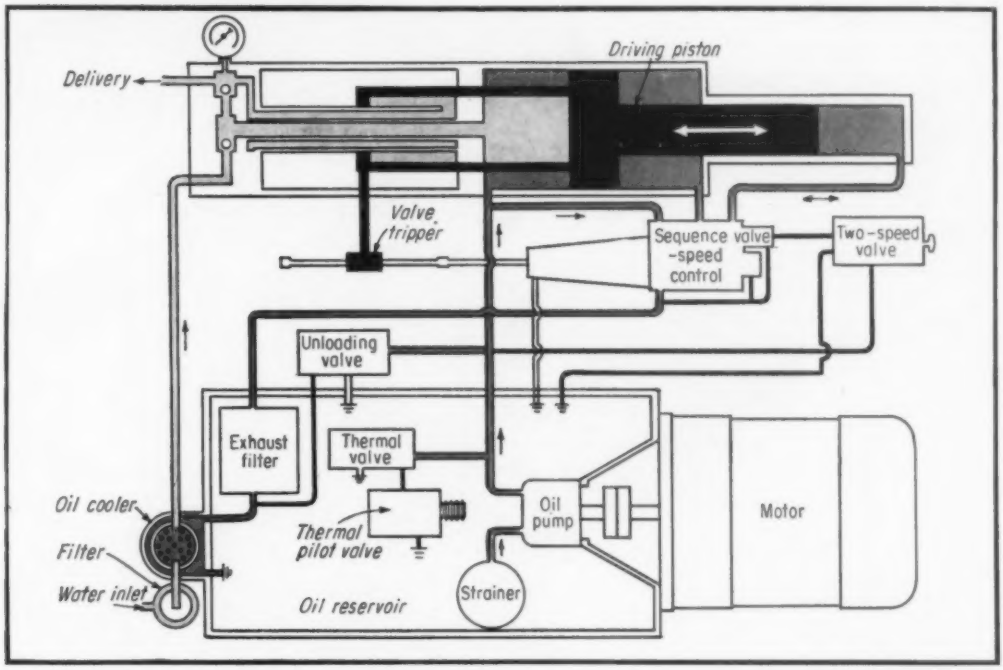
Failure Diagram for Fluctuating Stress, Feb 16, p 66—Author's graphical way to determine safety factors when loads are fluctuating.

DESIGN FEATURES IN NEW PRODUCTS



Oil Drives Water for High Pressures

Reciprocating pump has no mechanical links in its driving system. Self-adjusting seals and automatic lubrication result in 1000-hr operation between service checks.



Oil pump is driven . . . by a direct-coupled electric motor and supplies high-presure oil to the driving cylinder. Piston strokes are reversed by a tripper which controls the sequence valve. Piston on the water side of the pump is fixed, with a sleeve on the driving piston acting as a moving cylinder.

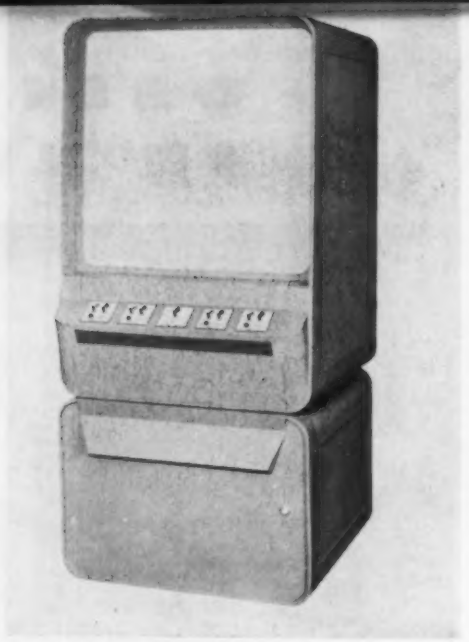
Overload protection is provided by an unloading valve that permits the pump's discharging to the reservoir. This prevents the pump from working against a relief valve when overloaded. The unloading valve allows the pump to idle, using little power, and automatically restarts the pump when pressure is reduced.

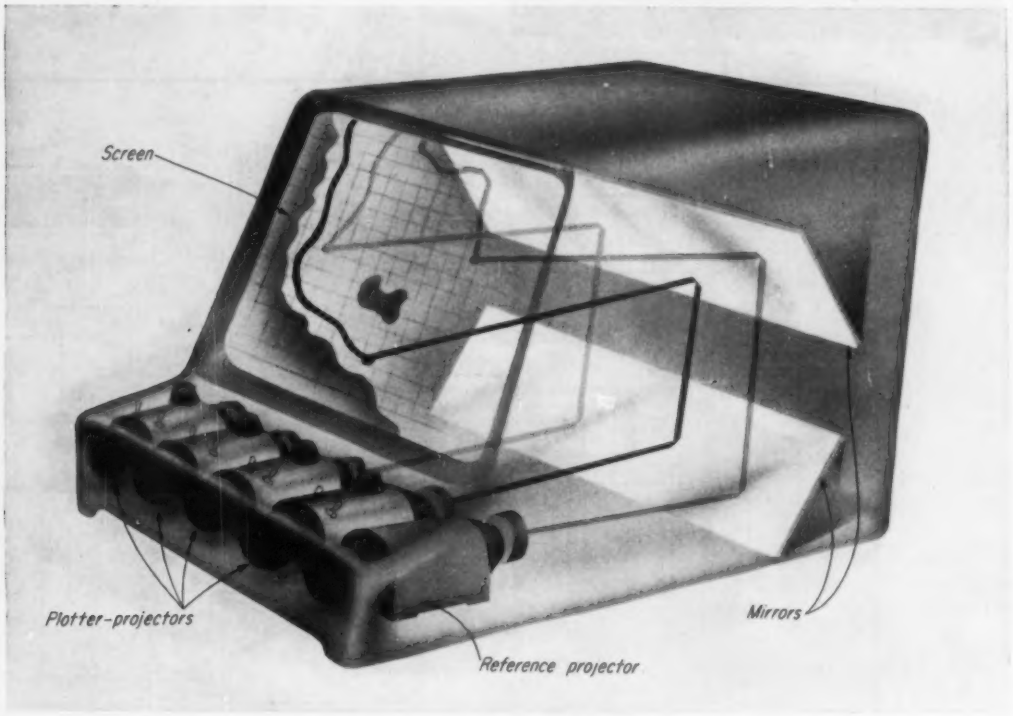
All working parts are lubricated by hydraulic fluid during operation and do not require routine attention. Self-adjusting seals are replaced only when performance is affected or visible leakage from the water gland becomes excessive.

PS . . . Designed to pump water from deep coal mines and for coal-infusion duty, the unit delivers 500 gal per hr at 3000 psi. Power is supplied by a 25-hp induction motor running at 1450 rpm. Totally enclosed pump has all controls and instruments on the front panel. Single control button is for duty selection. Hydraflo pump is produced by Tangyes Ltd, Cornwall Wks, Smethwick Birmingham, Eng.

Magic Lantern Throws Data in Colors and 3-D

First application you think of for this integrated system is monitoring the movements of aircraft in a congested area—you see not only the present locations of the planes but their flight patterns. Actually, the battery of projectors will throw any conventional data onto large-scale plotting board or viewing screens.

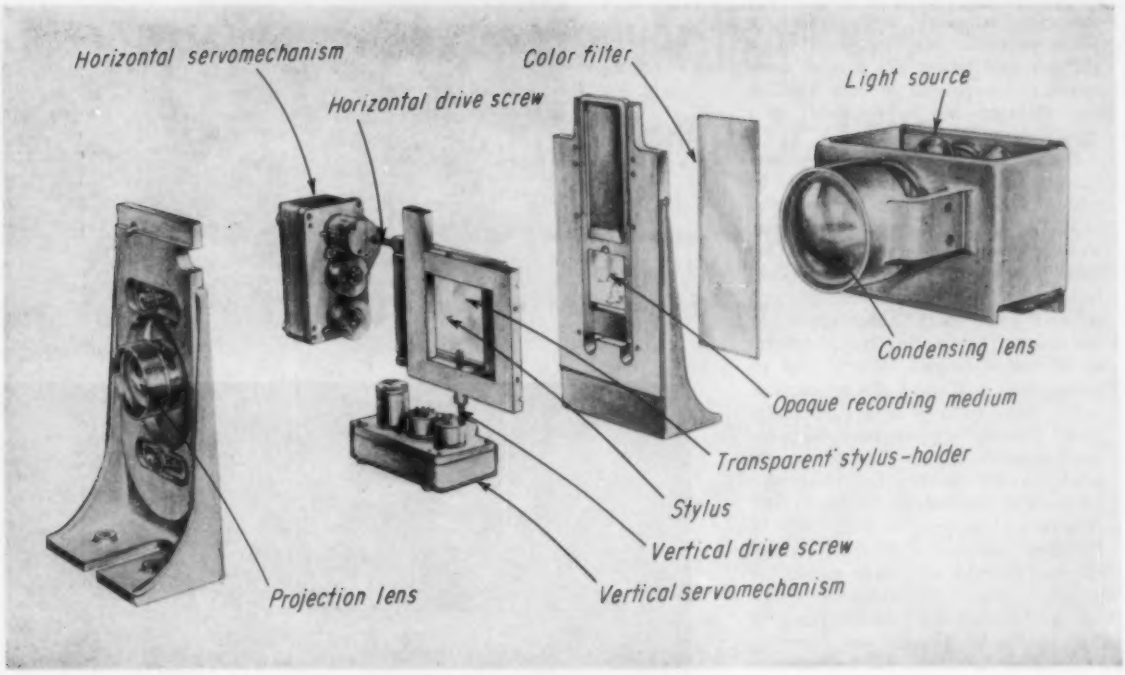


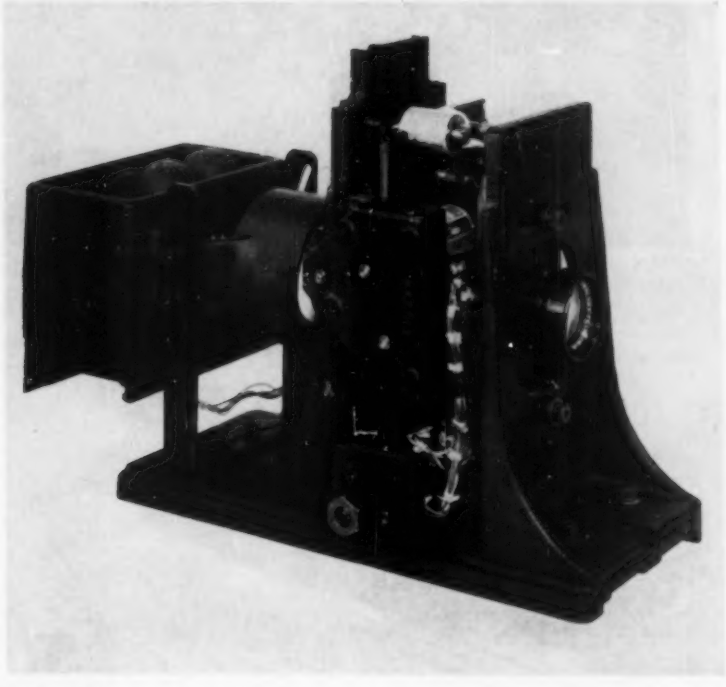


PS . . . "Iconorama" solves several problems encountered with conventional methods of showing the relationship among two or more constantly varying phenomena. Unlike an ordinary automatic plotter it allows a visual presentation that is multichannel and does away with need for moving arms and inking problems. Data for the displayed information can be fed directly from radar equipment, eliminating errors and the time-lag of manual plotting. Reference data such as charts or maps can be superimposed directly over the existing plots. Conorama is produced by Fenske, Fedrick and Miller Inc, Los Angeles.

Display console . . .
contains a battery of projectors which plot the analog data upon a translucent screen. A folded optical path is used to reduce the enclosure-size required. Four of the basic units are two-dimension plotting projectors, the fifth is a reference projector. The reference unit does not have servomotors. It does, however, have manual adjustments for positioning reference information needed for the data being plotted.

Projectors can be located wherever the chosen display method requires. For larger display areas, an opaque screen can be used, with the projector in front. Another way is to have a plotting board occupy an entire room, with the projectors overhead. When two or more projectors are used, identification of individual traces is accomplished by color filters.





Basic unit . . .
of the system is a plotter-projector. It can be used by itself, or as part of a multichannel battery. In either case the unit is actuated by servomechanisms that respond to dc analog voltages supplied by radar tracking units, computers or other data sources that provide the signal.

The projector contains an osmium-tipped stylus, of 1-mil radius, mounted in and indexed by a transparent stylus-holder. This holder is positioned in the X and Y axis by the horizontal and vertical servomechanisms. As it moves, the stylus contacts a glass slide that is coated with an opaque material and located in the focal plane of the projector. This coating is tough enough to withstand damage by normal handling but soft enough to be removed by the stylus.

Removal of the coating gives a recording of the movement of the stylus. The scribed lines, in turn, allow light from the illuminating lamp to pass through them and be projected onto a screen.

Information from a function generator may be fed into the system for identification of traces or other plots. Dual lamps with automatic switching provide uninterrupted operation in case of lamp burnout.

Positive identification of individual traces can be accomplished by switching individual projectors on or off. When a plot has been completed, the recording medium can be replaced or moved to an unused portion by a slide advance mechanism.

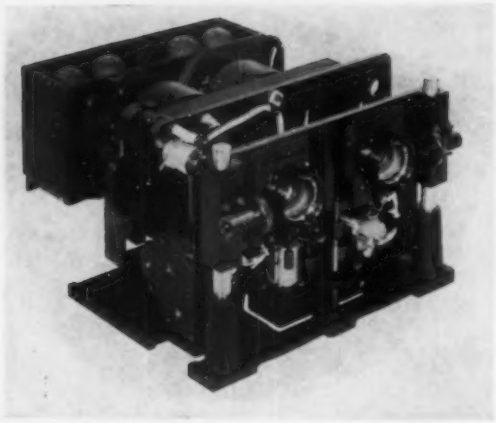
The standard plotter-recorder is used for all recording regardless of the size of plotting area required. Over-all accuracy and speed of response are not linked to the size of display, but to ability of the plotter servos to follow input signals, because all magnification is accomplished optically. The plotter uses miniature, low-inertia components and produces smooth, accurate plots at high plotting speeds. Recording accuracy is 0.1%, with 1.5 sec required for full-scale deflection.

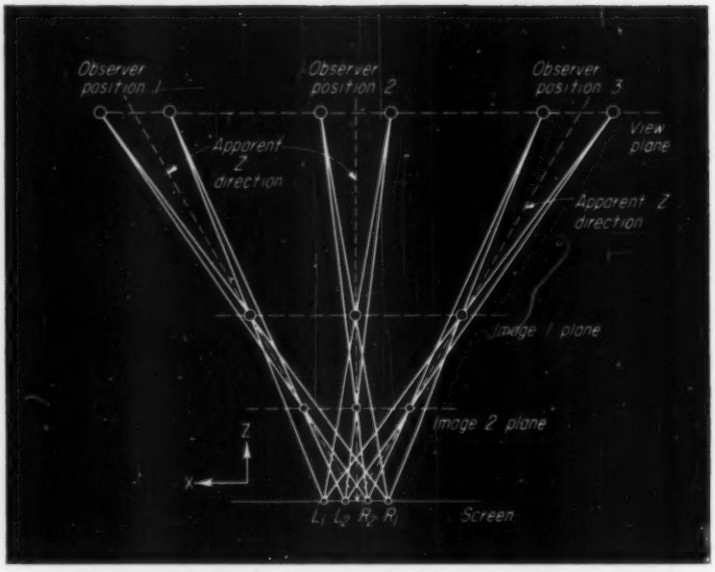
For 3-D projection . . .
two changes are made in the ordinary two-dimensional setup: (1) a pair of the basic plotter-projector units are used where one was used before; (2) a third servomotor is incorporated in each unit, so that the trace can be positioned in a third Z axis.

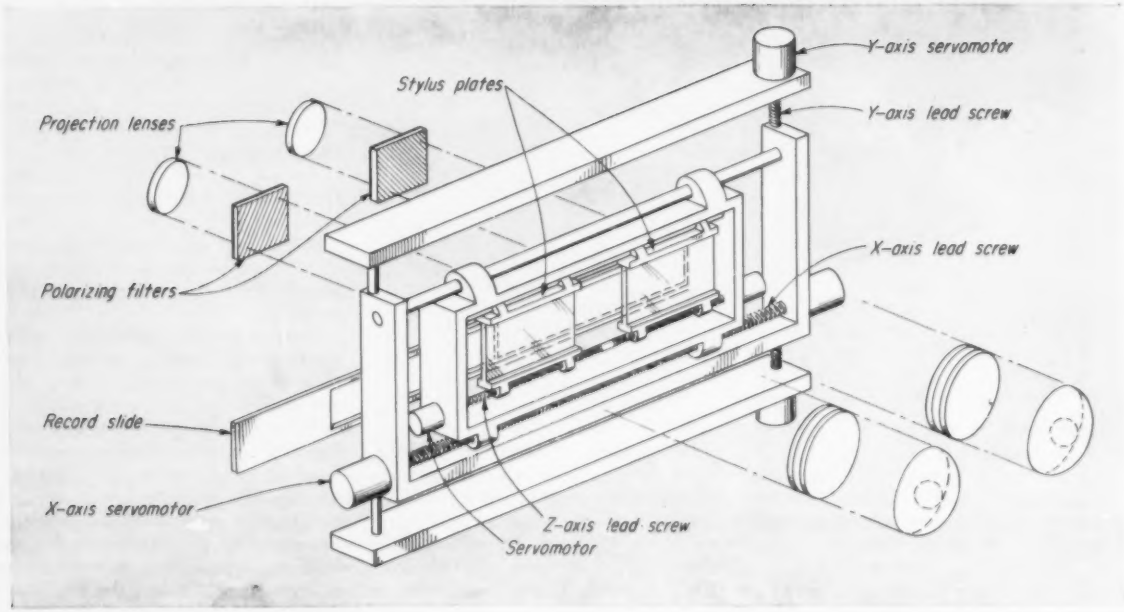
Pairing two projectors on a common frame allows a stereoscopical effect to be attained. With each of the two projectors displaying each data trace—two separate plots are generated, one for each eye. One trace is polarized vertically; the other, horizontally. When viewed through polaroid lenses both traces appear as one image. The resulting two plots seem to be one, suspended in space and retaining accurate X and Y plot information.

The image given by both traces is displaced from the screen by some finite distance along the Z axis. This distance depends on how far the two component images are horizontally displaced from each other. The apparent image seen by the viewer is located at the intersection of the line of sight from each eye to the projected image. The apparent image therefore appears closer to the viewer as the distance between the two traces increases along the Z axis. The true relationship between the plotted trace and the background reference map or scale is not affected by changes in the observer's position.

The third-dimensional information Z axis) is applied to the plotter-projector through a separate subchannel. After passing through its servoamplifier, the Z axis signal is applied to a servomotor which drives a leadscrew. This causes both cutting styli to move horizontally, but in opposite directions and by equal amounts.

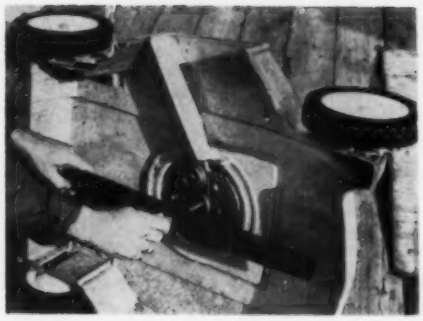




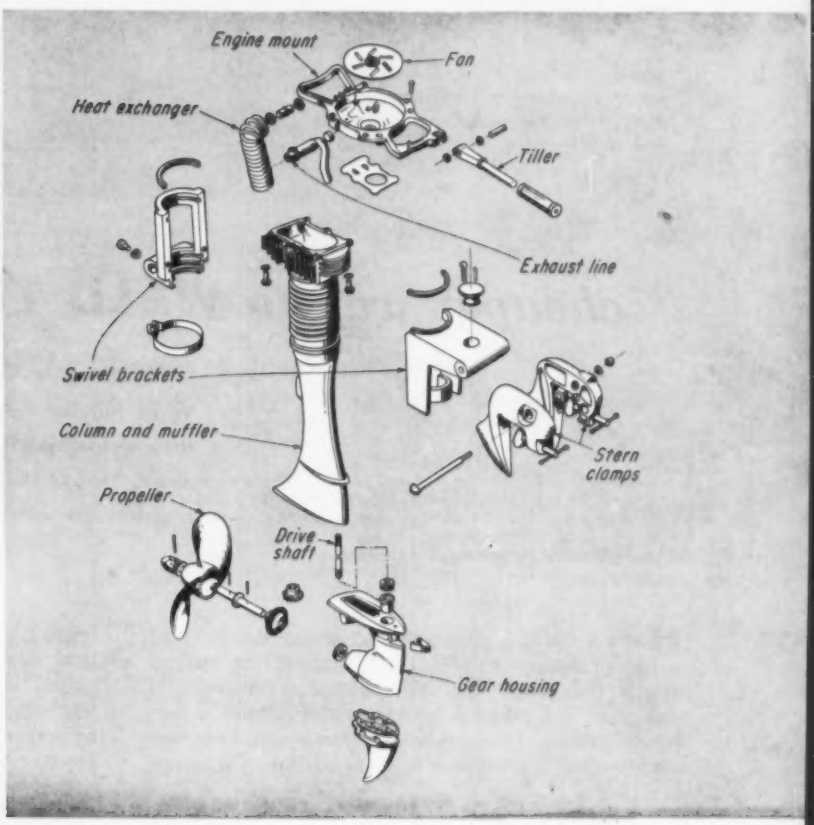


This Convertible Handles Lawn or Lake

The same power package that runs the rotary mower also speeds an outboard motorboat. You bolt it to either the mower chassis or propeller-shaft extension.

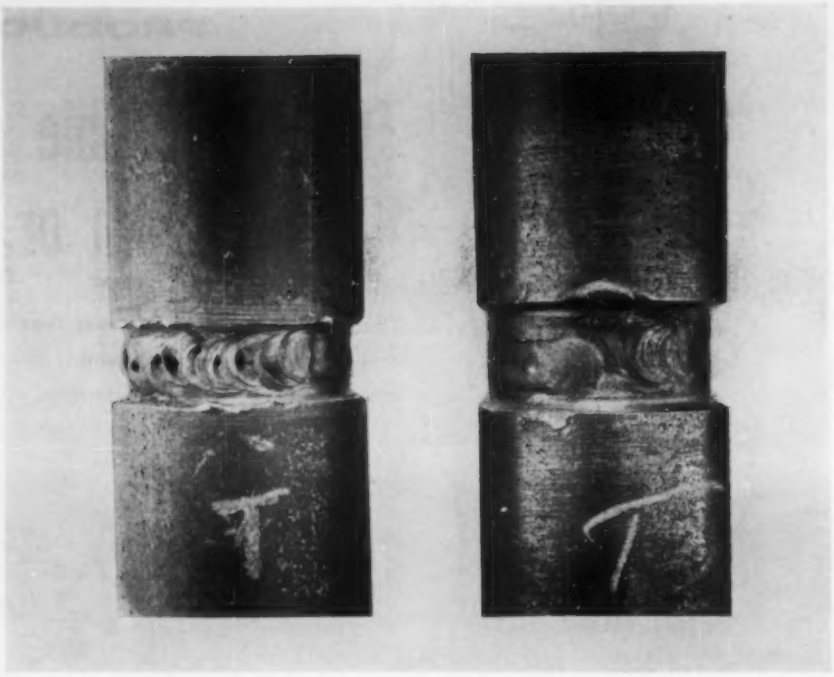


From grass to water . . .
can be done in a hurry. Disconnect the throttle control, mower blade, muffler and engine hold-down bolts from the mower motor. Install the cooling fan, propeller assembly and heat exchanger on the engine and it's ready to clamp on the transom of any boat. Open-end wrenches and screwdriver are the only tools required for conversion.



Outboard conversion kit . . .
is basically a standard outboard shaft-propeller assembly, with a special engine mount for the mower motor. To reduce noise, exhaust gases are directed through the column to an underwater outlet in the gear housing. The swivel brackets are bolted around the column to allow the entire motor-and-shaft assembly to turn for steering. Stern clamps bolted to the forward swivel-bracket hook over the boat transom and lock the motor to the boat by screw clamps.

PS . . . Outboard mower is powered by a 2½-hp, 4-cycle engine with a rated speed of 3600 rpm. Impulse starter on the engine provides easy starting without tedious rope pulling. Engine is produced by Tecumseh Products Co, Tecumseh, Mich. Mower-outboard assemblies are produced by ACCO Power Products Div, American Chain and Cable Co Inc, Exeter, Penna.



Insert rings eliminate porosity in inert-gas welds. Bubbling in ½-in tubing (left) is avoided (right) by fusing-in a consumable insert ring with modified silicon content.

cheaper way to WELD TUBES

When tubular shapes must stand high pressure, their welded joints need sound roots. Time-cost analysis shows that, of the different methods, fusing an insert ring into the critical area is cheapest in the long run.

HELMUT THIELSCH, *metallurgical engineer*
Grinnell Co Inc

Here's a welding procedure that proves the cheapest way is not always the one that looks simplest. The method fuses a thin insert ring into the root of the weld to strengthen that danger point when welding stainless tubing. Slightly modified, technique gives a cost advantage when welding high pressure joints in small tubular shapes of carbon steel.

Accompanying table, based on a time-and-cost analysis, shows that though the insert ring costs $2, total welding cost runs 10% less than with two rival methods. Savings come from faster welding and fewer defects that need rewelding.

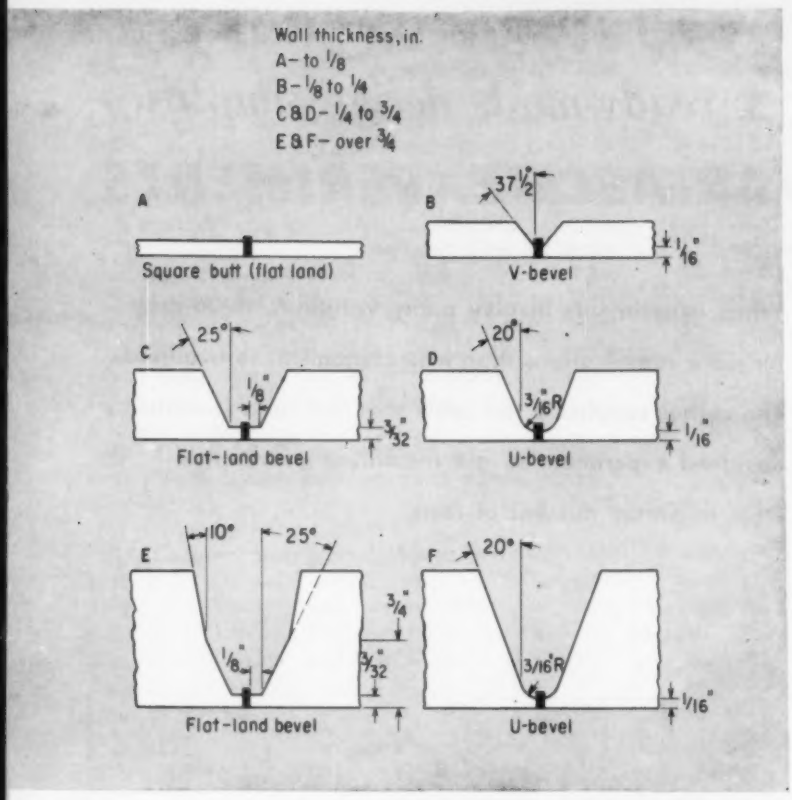
Any method should give complete fusion at the root. One method, conventional arc welding, with a consumable electrode, gets such fusion by joining both tubes to a backing ring at bottom of the weld. Such rings prevent burn-through of the tube wall. However, in small tubular shapes, the ring will restrict flow of fluid through the tube.

Therefore, a second method, tungsten arc welding—which is more precisely controlled—must be specified for at least the first weld pass. This eliminates need for the backing ring but introduces another problem. Carbon steel tends to bubble when welded—even when fully "killed" or deoxidized with aluminum or silicon during their original melting. Some improvement can be had by purging the interior of the tube with inert gas. This however takes time and requires additional fixtures.

But results are even better with the third method—thin insert rings which are fused into the weld joint itself. Though this means an added part, it's cheaper in the long run. The three methods are compared in the table on facing page.

Special Ring Material

Highest-consistency welds with the consumable-ring technique were given by ring material slightly modified with silicon and manganese for added deoxidizing of the molten weld metal. In tungsten inert gas (tig) welding, the resulting bead is about 30% insert-ring material; balance is parent base metal. This dilutes the higher silicon in the ring and keeps the weld deposit within base-metal specifications, while adding enough silicon for metallurgical soundness. Consumable insert rings for



Recommended joints for welding with consumable insert rings. Although normal edge bevels are satisfactory, most consistent results have been made with flat land bevels with 3/32-in. land.

Cost Comparison for Welding Carbon Steel Pipe

(For 6-in. schedule 40 pipe; repair time based on 100 production welds)

METHOD	LABOR TIME				COST				
	Setup (incl. tack weld) Min.	Weld, Min.	Clean, Min.	Repair, (grind, reweld) Min.	Electrode, @ $0.16 per lb	Consumable insert ring	Shielding and purging gas	Labor and overhead @ $5 per hr	Total cost
Root pass tungsten inert-gas arc welded, completed by shielded metal-arc	8	34	6	26	0.12	....	0.20	6.18	6.50
Interior of tube purged with inert gas	17	32	6	18	0.12	....	0.35	6.09	6.56
With consumable insert ring, no purging	7	28	6	3	0.12	2.00	0.20	3.67	5.99

killed steel would require less modifying with silicon or aluminum than for rimmed or semi-killed. Where silicon is the primary deoxidizer in the ring, the following minimums should be specified.

% Silicon in base metal	Min % of silicon in ring
under 0.05	0.35
0.05 - 0.15	0.30
over 0.15	0.20

Where aluminum or other deoxidizers are in base metal and insert rings, these minimums are changed slightly.

EDITOR'S NOTE: Other recent articles on design of parts and systems for high-pressure fluid flow:

Buckling in Hydraulic Tubing, May 11 '59, p 71. Because fluid columns buckle in much the same way as solid columns, similar equations can be applied.

Cast-in Tubing, May 12 '58, p 76. Design tips give low cost with pressure tightness, compactness and light weight.

Sandwich Manifolding, Feb 17 '58, p 88. When hydraulic circuits become a maze of tubing and fittings, simplify systems and connect components though built-in manifolds.

Metal Hose, Nov 11 '57, p 87. Discusses strength, leaktight service, and flexibility of various types of metal hose.

Higher Pressures for Mobile Hydraulics, Oct 28 '57, p 60. The 3000-to-6000 psi circuits offer a lower cost answer in many applications.

Maintenance Advice for Fluid Circuits, Mar 17 '58, p 71. Checklist covers the principles—preventive and troubleshooting—that will keep hydraulic equipment working properly.

ready-made design simplifies

MULTI-VARIABLE EXPERIMENTS

When experiments involve many variables, there may be more combinations than it is economical to evaluate. The author supplies a test table that sets up a statistically designed experiment to get maximum information from minimum number of tests.

WILLIAM J HILL, *manager,*
Statistical Services Section,
Ford Instrument Div, Sperry Rand Corp

	Variable															
Test No.	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q
1	−	−	−	−	+	+	+	+	−	−	−	−	+	+	+	+
2	−	−	+	+	−	−	+	+	−	−	+	+	−	−	+	+
3	+	+	−	−	−	−	+	+	−	−	+	+	+	+	−	−
4	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−
5	−	+	−	+	+	−	+	−	−	+	−	+	+	−	+	−
6	−	+	+	−	−	+	+	−	−	+	+	−	−	+	+	−
7	+	−	−	+	−	+	+	−	−	+	+	−	+	−	−	+
8	+	−	+	−	+	−	+	−	−	+	−	+	−	+	−	+
9	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
10	−	−	+	+	+	+	−	−	−	−	+	+	+	+	−	−
11	+	+	−	−	+	+	−	−	−	−	+	+	−	−	+	+
12	+	+	+	+	−	−	−	−	−	−	−	−	+	+	+	+
13	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+
14	−	+	+	−	+	−	−	+	−	+	+	−	+	−	−	+
15	+	−	−	+	+	−	−	+	−	+	+	−	−	+	+	−
16	+	−	+	−	−	+	−	+	−	+	−	+	+	−	+	−
17	−	+	−	+	−	+	−	+	+	−	+	−	+	−	+	−
18	−	+	+	−	−	+	+	−	+	−	−	+	+	−	−	+
19	+	−	−	+	−	+	+	−	+	−	−	+	−	+	+	−
20	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−
21	−	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+
22	−	−	+	+	−	−	+	+	+	+	−	−	+	+	−	−
23	+	+	−	−	−	−	+	+	+	+	−	−	−	−	+	+
24	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
25	−	+	−	+	+	−	+	−	+	−	+	−	−	+	−	+
26	−	+	+	−	+	−	−	+	+	−	−	+	−	+	+	−
27	+	−	−	+	+	−	−	+	+	−	−	+	+	−	−	+
28	+	−	+	−	−	+	−	+	+	−	+	−	−	+	−	+
29	−	−	−	−	+	+	+	+	+	+	+	+	−	−	−	−
30	−	−	+	+	+	+	−	−	+	+	−	−	−	−	+	+
31	+	+	−	−	+	+	−	−	+	+	−	−	+	+	−	−
32	+	+	+	+	−	−	−	−	+	+	+	+	−	−	−	−

Master Design Table

Summarized here are tests that must be run for any number of 2-level variables up to 16. These tests will uncover all main effects and some interaction effects. To determine which tests to make, and how many, assign a letter to each variable and, following the last letter assigned, draw a line down the table until it intersects a horizontal line. These two lines enclose the tests to be run. The dotted line in table above, for example, shows the 16 tests that will be needed when an experiment has 6 variables. The plus signs indicate upper level of a variable, minus signs indicate lower level. These tests are randomly arranged and combined with retests shown at right.

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Getting the most from your experimental dollar? That depends on your test procedure. Too many tests take too much time. Too few mean that some relationships will be ignored. The method shown here allows evaluation of all variables that have an independent effect on output (main effects) and some pairs of variables that work together to change the output (interaction effects).

This fractional factorial design therefore lies somewhere in between two other common methods that are tailor-made to suit a test procedure. These two have been previously discussed in PRODUCT ENGINEERING:

(1) The full factorial design gives the most information ("Experiments That Have Statistical Certainty," July 6 '59) but is usually too costly when there are a large number of variables.

(2) The Latin Square design reduces experimental work ("Latin Squares for Fewer Tests, Same Accuracy," May 12 '58) but neglects evaluation of some effects that can influence the result.

The fractional factorial method is an easy compromise that combines advantages (and some drawbacks) of both.

It is straightforward and easy to follow. First determine the number of variables, then refer to the Master Design Table to find what tests to make. The accompanying chart shows how many tests to repeat and what interaction groups to evaluate. Main effects and interaction effects are analyzed in the usual manner, as shown in the example on the following page.

Because this is not a full factorial design, however, there is insufficient data to evaluate all interactions.

Instead, critical interactions between two variables are singled out for analysis. (Interactions between three or more variables are rare and, furthermore, difficult to explain.) The critical interactions represent a group whose members cannot be dissociated from each other—if one interaction in each group is proven not significant, the other interactions can be ignored. Similarly, if one interaction is significant, additional tests will be required to show exactly which one of the group is causing the variation.

This design is also limited to experiments where variables have only two levels (the upper and lower limits of a tolerance range, for example). This limitation is not a serious one, however. In most experiments, a variable is changed from one level to another to find whether a difference exists—not to find how much difference. If this is the purpose of the experiment, two levels will usually suffice to show it. In general, it is not worth the increased number of tests to design a fractional factorial that has variables at three levels.

Number of Variables	Number of Tests	Number of Repeat Tests	Total	Interaction Groups (Assuming all variables used.)
2 – 4	8	4	12	**AB** (CD) **AC** (BD) **AD** (BC)
5 – 8	16	4	20	**AB** (CD, EF, GH) **AC** (BD, EG, FH) **AD** (BC, EH, FG) **AE** (BF, CG, DH) **AF** (BE, CH, DG) **AG** (BH, CE, DF) **AH** (BG, CF, DE)
9 – 16	32	8	40	**AB** (CD, EF, GH, JK, LM, OQ, NP) **AC** (BD, EG, FH, JL, KM, NQ, OP) **AD** (BC, EH, FG, JM, KL, NO, PQ) **AE** (BF, CG, DH, JN, LQ, MO, KP) **AF** (BE, CH, DG, KN, MQ, JP, LO) **AG** (BH, CE, DF, LN, JQ, MP, KO) **AH** (BG, CF, DE, MN, KQ, JO, LP) **AJ** (BK, CL, DM, EN, FP, GQ, HO) **AK** (BJ, CM, DL, EP, FN, GO, HQ) **AL** (BM, CJ, DK, EQ, FO, GN, HP) **AM** (BL, CK, DJ, EO, FQ, GP, HN) **AN** (EJ, FK, HM, BP, CQ, DO, GL) **AO** (EM, FL, HJ, BQ, CP, DN, GK) **AP** (EK, FJ, HL, BN, CO, DQ, GM) **AQ** (EL, FM, HK, BO, CN, DP, GJ)

How Many Retests?

To compute experimental error, some tests are repeated—the number depends on the number of variables and is shown in the third column of this chart. Also shown are the interactions. They are grouped to indicate which ones are independent, which are dependent. Only underlined interactions are chosen for analysis; if they are not significant, none of the combinations in brackets are significant. But if, for example, interaction AF were found significant in a seven-variable experiment, there is not enough data to tell whether AF is actually the significant interaction or whether the significant interaction is one of the others in that group. Additional tests will be necessary to find which of the related interactions (AF, BE, or DG) is significant. (Notice that interaction CH will not be included in a seven-variable experiment because there is no H variable.) It is sometimes possible to reduce the number of additional tests by eliminating those combinations unlikely to affect output.

(CONTINUED NEXT PAGE)

EXAMPLE OF FRACTIONAL FACTORIAL DESIGN

Problem: A breadboard model of a circuit contains 16 different components. Some of them are so critical that a change within the tolerance limits has an appreciable effect on circuit output—when a 95-ohm resistor is replaced by a 105-ohm resistor (both within the tolerance range) there is a measurable change in output. Design an experiment that shows which components, or pairs of components, must be held within critical tolerance levels.

Solution: Because there are 16 variables, Master-design table shows it will be necessary to make 32 tests (plus 8 repeat tests to find experimental error). Sequence of tests is scrambled in a random manner; retests (marked with asterisk) are chosen at random and distributed throughout the test sequence. (A table of random numbers helps arrange test sequence and choose repeal tests.) Output for the 40 tests is shown below.

	Component																
Test No.	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	Output
1	−	−	+	+	−	−	+	+	−	−	+	+	−	−	+	+	0
2	+	+	−	−	−	−	+	+	−	−	+	+	+	+	−	−	−25
3	+	−	+	−	+	−	+	−	−	+	−	+	−	+	−	+	+44
4	+	−	−	+	−	+	+	−	−	+	+	−	+	−	−	+	−65
5	−	−	−	−	+	+	+	+	−	−	−	−	+	+	+	+	+25
6	−	−	+	+	−	−	+	+	+	+	−	−	+	+	−	−	−48
7	+	+	−	−	+	+	−	−	+	+	−	−	+	+	−	−	−12
8	−	−	+	+	+	+	−	−	−	−	+	+	+	+	−	−	+82
*1	−	−	+	+	−	−	+	+	−	−	+	+	−	−	+	+	−10
9	−	+	+	−	−	+	+	−	+	−	−	+	+	−	−	+	+37
10	−	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+	−62
11	−	−	−	−	+	+	+	+	+	+	+	+	−	−	−	−	−59
12	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+78
13	−	−	+	+	+	+	−	−	+	+	−	−	−	−	+	+	+48
14	−	+	−	+	+	−	+	−	+	−	+	−	−	+	−	+	+66
15	−	+	−	+	−	+	−	+	+	−	+	−	+	−	+	−	−25
*7	+	+	−	−	+	+	−	−	+	+	−	−	+	+	−	−	−16
16	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0
17	+	−	+	−	−	+	−	+	+	−	+	−	−	+	−	+	−5
*18	+	−	−	+	+	−	−	+	−	+	+	−	−	+	+	−	−53
19	+	−	−	+	−	+	+	−	+	−	−	+	−	+	+	−	+17
20	+	+	−	−	−	−	+	+	+	+	−	−	−	−	+	+	−106
21	−	+	+	−	−	+	+	−	−	+	+	−	−	+	+	−	+3
22	−	+	+	−	+	−	−	+	+	−	−	+	−	+	+	−	+43
23	+	−	+	−	−	+	−	+	−	+	−	+	+	−	+	−	−46
24	+	−	−	+	+	−	−	+	+	−	−	+	+	−	−	+	+18
25	+	+	+	+	−	−	−	−	+	+	+	+	−	−	−	−	−6
26	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−103
*26	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−111
*16	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+12
*24	+	−	−	+	+	−	−	+	+	−	−	+	+	−	−	+	+28
27	−	+	+	−	+	−	−	+	−	+	+	−	+	−	−	+	+4
28	+	+	+	+	−	−	−	−	−	−	−	−	+	+	+	+	+36
29	−	+	−	+	+	+	+	−	−	+	−	+	+	−	+	−	−14
30	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+12
*21	−	+	+	−	−	+	+	−	−	+	+	−	−	+	+	−	−3
*12	+	−	+	−	+	+	+	−	+	−	+	−	+	−	+	−	+94
31	+	+	−	−	+	−	−	−	−	−	+	+	−	−	+	+	+67
32	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−	+42
*30	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+16

REPEATABILITY

Compute experimental error by averaging difference in outputs among identical tests.

Repeat tests	Difference
1	10
7	4
26	8
16	12
24	10
21	6
12	16
30	4
Total	= 70
Average, R =	8.75

It is possible that a large difference among repeated readings is caused by a reading error. If so, it will fall beyond the statistical limit (UCL = $2.5R$) and will have to be discarded. None of these differences exceeds the limit (21.9), however.

In subsequent computation, disregard repeat tests; average both readings to get true reading.

MAIN EFFECTS

(a) Compute average output, X', for all tests by adding output for all tests and divide by number of tests. In this case, the average, $X' = 0$.

(b) Compute control limits for main effects

$$\text{control limits} = X' \pm \frac{t_\alpha R}{1.128\sqrt{d}}$$

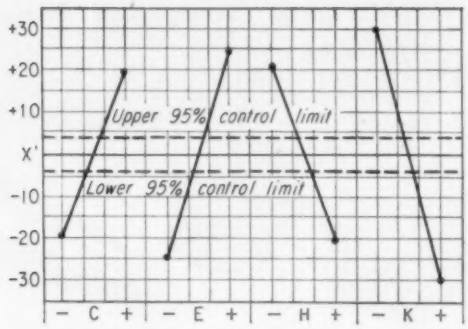
Where R is experimental error, d is degrees of freedom (number of tests for each point plotted in main-effects chart, less one) and t_a is taken from statistical tables at d degrees freedom and confidence level, $a = 0.05$.

$$\text{control limits} = \pm \frac{(2.131)\ (8.75)}{1.128\ \sqrt{15}} = \pm 4.26$$

(c) Compute effect of each variable on output and compare with control limits. To find effect of variable K compute average output for all tests where upper-limit component K is in the circuit (K^+) and repeat for lower-limit component (K^-).

$$K^+ = \frac{-478}{16} = -29.9,\ K^- = +29.9$$

Repeat this procedure for each component and plot on chart with upper and lower confidence limits. The four components that were found to be significant are plotted in chart below.



INTERACTION EFFECTS

The chart indicates that 15 interactions will have to be evaluated to determine if any of them are significant. To compute interaction between A and M:

(a) Find two-way averages for the four possible combinations of A and M (A-plus with M-plus, A-plus with M-minus, A-minus with M-plus, A-minus with M-minus).

Average of A-plus with M-minus, for example, is

$$\frac{80}{0} = 10.$$

(b) Eliminate variations caused by main effects by subtracting these from over-all average.

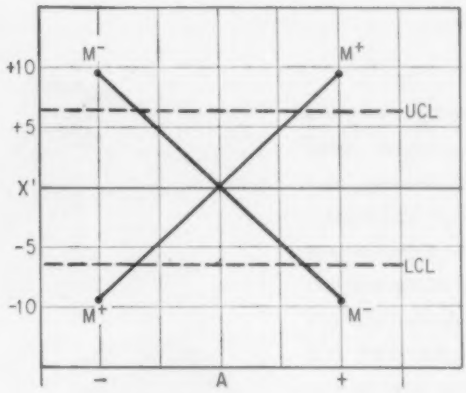
$$X' - A^+ = 0 - 0.12 = -0.12$$
$$X' - M^- = 0 - (-0.62) = +0.62$$

(c) Subtract interaction effects in (b) from two-way average in (a):

$$10 - (-0.12) - 0.62 = +9.5$$

Plot each of these on interaction control chart with control limits computed as before:

$$\text{control limits} = 0 \pm \frac{2.365\ (8.75)}{1.128\ \sqrt{7}} = \pm 6.92$$



Interaction AM is the only one found to be significant. But it is not known whether AM is really the significant interaction or one of the related interactions (BL, CK, DJ, EO, FQ, GP, HN).

Normally it would be necessary to conduct more tests to find which is actually the significant one. In this case, however, the engineer noticed that the interaction effect was small compared to main effects and chose to correct only the variation of the main effects.

CIRCUIT CORRECTION

Because components C, E, H and K each have an effect on the output which causes it to exceed specified output, the obvious conclusion is to tighten the tolerance on each component to bring the output within specification. The engineer found, however, that components C, E and H could not be purchased to a tighter specification. The problem was solved by inserting these three components into the circuit first and finding the required value for component K with a variable-resistance element (decade box). Although this is a rather slow procedure for a production operation, it was judged to be well worth the effort.

FOR REPRINT of above article, just check P 24 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: For other statistical methods that can save testing time, see:

"Design of Experiments—Blind Spot for Researchers," Sep 22 '58, p 34. The reasons why statistically designed experiments are faster, give more information than experiments conducted along classical lines.

"Latin Squares for Fewer Tests, Same Accuracy," May 12 '59, p 92. An ancient puzzle-game shows how to reduce the number of tests.

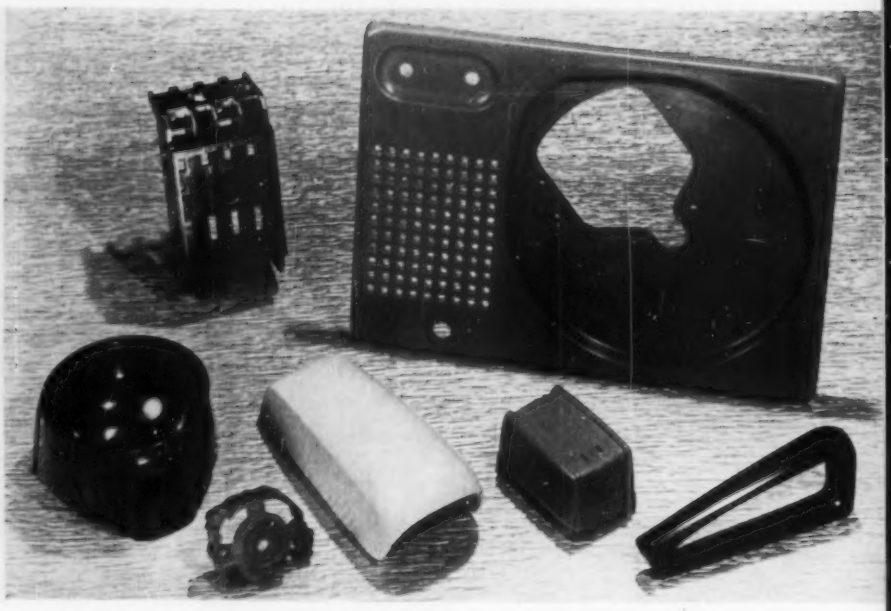
"Experiments That Have Statistical Certainty," July 6 '59, p 66. Step-by-step procedure for programming and analyzing a full-factorial experiment.

"Regression Analysis Digs Out Equations From Scattered Data," July 20 '59, p 62. A statistical way to find the exact relationship between two or more variables.

speed your new product with . . .

CAST EPOXY MODELS

Plastic casting converts your new product ideas quickly and directly into actual parts or assemblies. This allows simultaneous appraisal of many designs by key departments—engineering, production and sales. Here's the know-how you'll need for casting shortcut prototypes.

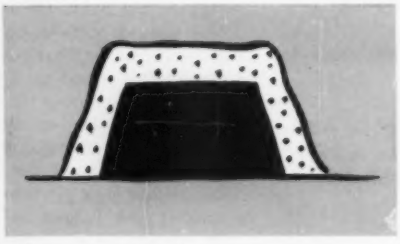


ALFRED W WAKEMAN
Alfred Wakeman Industrial Design
Durham, Conn

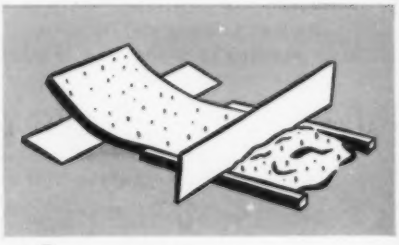
THE AUTHOR is an industrial designer who knows the design engineer's problems—because he is partly an engineer himself. Halfway through Yale engineering school he decided that "industrial designers have all the fun in new-product development," so he shifted gears and finished his studies at the Rhode Island School of Design. Explaining importance of the clay-and-epoxy modeling procedure in his own work, Wakeman says:

"Pencil sketches should not have to bear the responsibility for heavy investments in drafting, pattern making and machining required to prove or disprove an idea. Nor do sketches satisfy the mounting demand for evidence of product success before tooling and promotion investments are made. Without the help of plastic models, these financial considerations tend to temper enthusiasm for any new design that smacks of the unusual."

THE BASIC



1 Make the cavity . . .
by laying up plaster ½ in. thick with spatula over pattern of part desired. Resulting cavity gives the exterior surface of the final cast epoxy model. Pattern can be clay, wood, metal or plastic; clay does not need mold release. Lift off cavity about ½ hr after lay-up, or at peak exotherm: sweating of plaster surface now makes parting from pattern easy.



2 Prepare clay . . .
for walls of the part being cast by spreading clay between guide-bars of correct thickness. Scrape off excess clay with straightedge. Remove guide-bars and loosen clay layer from table with thin straight blade drawn smoothly under full length.

Every engineer dreams of converting new-product ideas directly into truly realistic models, like those shown at left, before spending money on detailed prototype development. And every business manager dreams of converting such models into purchase orders before buying costly tooling. The engineer seeks proof of the idea's functional validity; the business manager wants "eye-appeal" proof of its public acceptance. This article describes a simple modelmaking process that can often satisfy both requirements quickly and at minimum cost.

Epoxy casting resins are the key element in the technique. By casting them into plaster molds made over clay models, a succession of ideas can be converted directly into parts for evaluation. This is the basic process but it need not end here. Using the best of the models, new and stronger cast-epoxy molds can be made over them. Now as many as twenty identical parts can be made for simultaneous evaluation by engineering, production, die shop, and test groups.

With a little more time, complete operating assemblies can be produced for use by sales, advertising or marketing departments. The investment cost for trying this technique (see materials list, last page) for the first time is estimated at well under $100.

Plastic casting as an aid to new-product development is necessarily as much a management process as a shop process. Practical information on the many materials involved is limited, explaining why such model-making can become an experiment as well as an end in itself. Furthermore, success depends on your mental agility as a caster. You will have to visualize from positive to negative and back, planning each job for the stage where it's done quickest and easiest, knowing what materials are best for the number of parts required, their tolerances, finish, color and performance.

Jobs for These Models

The basic process, along with the variants shown in the two examples, can be applied in several areas. Simpler applications are for:

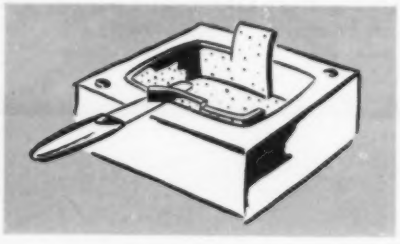
- Housings—as rough studies, or finished for final appearance and operations analysis.
- Detailed mechanical parts, where more than one piece is needed and machining costs per part are high.
- Representations of diecastings and forgings needed for studying appearance, assembly, and mechanical action.
- Patterns for sand-casting metals and vacuum-forming plastics.
- Patterns for die cavities to be copied directly in steel, bypassing specification of contours on paper.

When handled by the professional modelmaker, the basic process offers refinements that permit more stringent applications, such as:

- Prototype parts to production specifications on color, surface finish, and tolerance.
- Unusual material properties, such as transparency, flexibility, high-temperature resistance.
- High-density patterns for electroforming of prototype sheet-metal parts.
- Temporary tooling for injection molding of production thermoplastic parts.

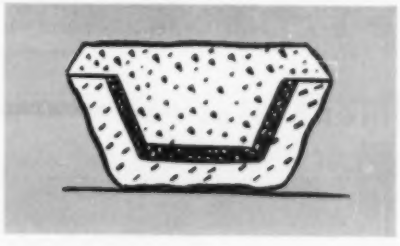
For jobs in the simpler category, the major concern here, the desired result always includes the time factor

PROCESS



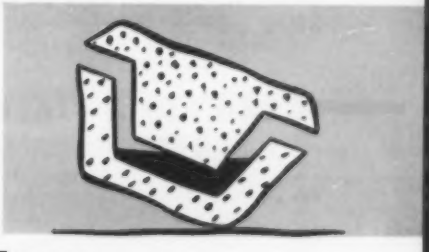
3 Line the cavity . . .

by cutting clay layer into appropriate widths and pressing them gently in place. Trim excess clay with spatula, flush with parting line. Clay lining should not have positive imperfections; negative imperfections are easily removed from the cast core by sanding. Objective is a core free from undercuts. Do not build bosses now; they are more easily cut into core when cast and dried. Chassis may be lightly pressed in place to mark screw locations, saving layout time on core.



4 Cast the core . . .

after first applying wax and indexing dimples to parting line of cavity. Remove core at peak exotherm. Dry thoroughly. Cut bosses and ribs. Drill holes for quick-opening jackscrews, if desired. Remove clay from cavity, and finish both core and cavity with thin shellac (let it soak in until no shine is left). Apply heavy coat of paste wax to both, and buff to high finish.

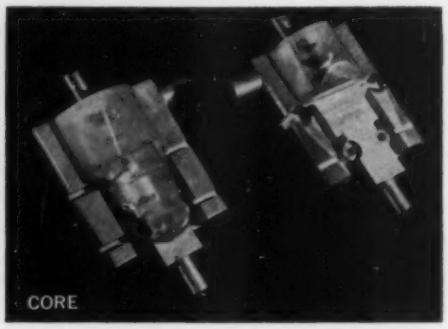


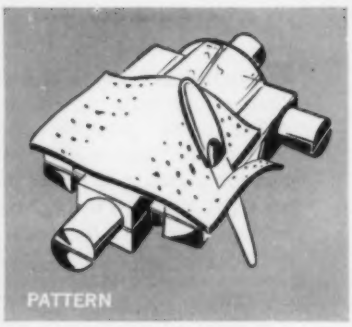
5 Cast the part . . .

by pouring catalyzed and pigmented epoxy into cavity and pressing core carefully in place. Tilt cavity before inserting core so trapped air can escape. Wipe away excess resin and cure at 90-110 F for about 3 hr. (Higher temperatures will cause plaster to absorb wax, making mold impossible to open.) Open mold with light mallet or jackscrews. Remove part, trim flash and buff if necessary.

Example 1—Thermostatic Control Plug

The problem: Design a plastic housing for an appliance control plug and make an operating model, working from engineering drawings for internal mechanism and contacts. Three holes are required for: electric cord, dial shaft, and temperature probe. Provide indicating arrow.





CORE: This is an inside-out job. Construct a model of the minimum internal cavity, including mounting bosses and ribs, from two positive cores—separating at a convenient parting line. Use aluminum for rectangular parts of cavity and build up odd-shaped portions with easy-to-cut Lucite. Clamp aluminum plates face-to-face so cores for three holes (photo) can be turned. Common clamping face forms parting line.

PATTERN: Prepare modeling clay to minimum thickness of housing. With core halves lightly stuck together with rubber cement, press a layer of clay over entire pattern. Add more clay and model to the desired appearance, including triangular hole for indicating arrow. Let hole cores protrude. Slit finished clay model into two halves with spatula along parting line. Lay each half, parting-line down, on flat surface.

and excludes the nonessential refinements. Thus, with the instrument-dial example below, the internal surface was unimportant and left unfinished; with the thermostatic control plug, the outer finish—though important—was secondary to shape and high-temperature resistance, so the resin chosen was a temperature-resistant epoxy, filled for low shrinkage. Buffing after casting gave a satisfactory finish for the job requirements.

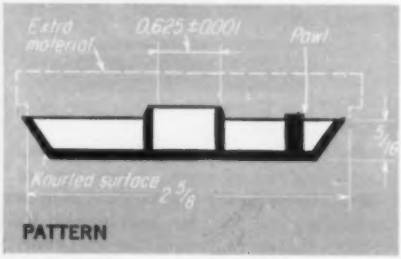
Epoxy Performance

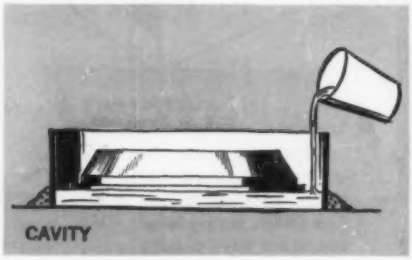
Epoxies are widely used in electronic encapsulations, adhesives, glass-reinforced laminates and corrosion-resistant coatings. Molding compounds based on these resins have appeared only recently, to answer the adhesion problem. Casting epoxies, aside from encapsulation, have been limited in structural applications to parts where production quantities are low because the casting process is time-consuming. Most castable epoxies are also excellent photoelastic model materials (*PE—July '57, p 135*).

How such epoxies perform under load becomes the logical question when they are cast as models that will be used functionally. Two basic casting resins were chosen because of the author's experience with their all-around utility. Their mechanical and physical properties are compared in the accompanying table with a standard phenolic molding resin. The detailed techniques covered here were developed with these two casting resins. However, many companies make epoxy casting resins, some of which may be suitable for this process.

Example 2—Instrument Dial

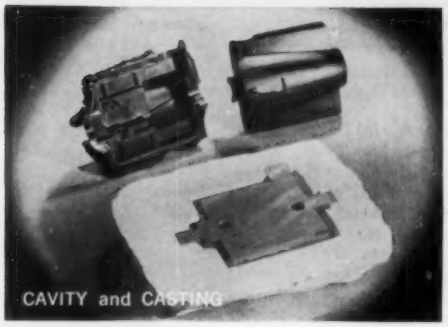
The problem: Make two instrument dials suitable for an operating prototype. External surface and knurling must be close to production quality; internal surface is not critical, except that hollow mounting hub requires close tolerance: 0.625 ± 0.001 in. One red and one blue dial needed.





PATTERN: Using aluminum (for finish), turn a solid model of dial exterior. Leave extra material beyond parting line for use later in locating the core during casting. Engrave knurl on an index head for precision. Polish all pattern surfaces.

CAVITY: Fasten pattern to a flat surface and wax both lightly. Form wall around model (sheet aluminum, stapled, works fine) to form outer edge of cavity; wax it and seal it to flat surface with modeling clay. Mix epoxy resin (gives better surface than plaster) for cavity in large paper cup, and pour over pattern slowly to avoid bubbles. Cover model by about ½ in. Cure under heat lamp; remove pattern and wall.


CAVITY and CASTING

ASSEMBLY

CAVITY AND CASTING: Cover two half-patterns with plaster and allow to set. Lift off two plaster cavities and thoroughly dry. Seal with very thin shellac and prepare for casting with heavy coat of paste wax, well rubbed in to fill pores. Strip clay from core halves, clean with acetone, and wax lightly. Insert screws as cores for threaded assembly holes.

Select E-C Stycast resin for casting—it has the better temperature resistance, and the finished part will be heated in operation. Mix resin and hardener in required proportion, pour into cavity and insert core (shown in empty mold, left) avoiding trapped air in boss recesses. After curing for 3 hr at 110 F, cut away flash with end-mill (light cuts, high speeds) flush with surface of core and cavity to establish parting line. Remove trimmed halves, sand and polish to desired finish.

ASSEMBLY: Install internal mechanism, probe, dial and cord (not shown). Clamp housing halves together with setscrews (beneath assembly) and test. For additional units save time by making a new mold in epoxy from already finished parts rather than hand-finish further sets. The epoxy mold will reproduce exactly the surface of the original parts plus parting agent.

PROPERTIES OF CASTING RESINS

Property	Stycast 2651	Castiplast 17	Phenolic
Specific gravity	1.55	1.55	1.37
Tensile strength, psi	9,000	4,640	7,000
Compressive strength, psi	16,000	13,000	30,000
Flexure strength, psi	15,000	8,350	11,000
Izod impact strength, ft-lb/in. of notch	0.3	0.4	0.3
Thermal expansion coeff, in./in. per °C × 10^{-6}	25	60	40
Water absorption (24 hr), %	0.1	0.2	0.7
Dielectric constant (60 cps)	4.4	5.79	5.6
Dissipation factor (60 cps)	0.02	0.19	0.07
Dielectric strength, v/mil	455	340	325

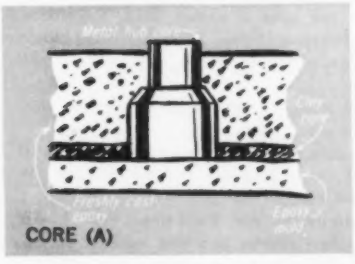
Casting Pointers

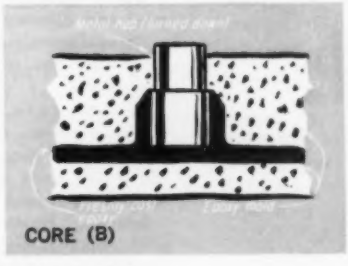
Here is a list of 10 rules which, if followed, will help you cast a wide variety of parts successfully:

1—TEST CASTINGS: Try some simple shapes before tackling a complex part. Follow the resin manufacturer's directions carefully, but don't expect a great deal of help from him on specific casting problems.

2—DRAFT: Molds with any depth require draft. Plaster molds need about 5° because surface is porous; epoxy molds need about 2° because surface is smoother.

3—MOLD MATERIAL: Select mold material for the number and complexity of parts desired. Plaster is good for 1 to 3 parts of broad contour and minor rib detail; make single parts with zero draft and undercuts by sacrificing

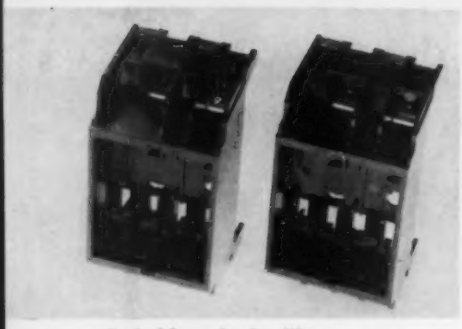

CORE (A)


CORE (B)

CASTING

CORE: Two steps are required to get close tolerance hub:
(a) Machine metal insert to hub OD, with knockout extension. Cement polished model hub in cavity, build up dial wall around it with clay layer. Finish clay to correct thickness with templet pivoting on hub model. Surround cavity with wall, ½ in. above cavity. Wax surfaces and pour core.
(b) Cure core, remove metal hub, rechuck and turn to dial hub ID. Mill slot in core for pawl. Clean out cavity, wax core and cavity. Reinsert hub pattern after waxing.

CASTING: Mix precolored Castiplast epoxy resin with hardener, pour into cavity, insert core (tilting to prevent bubbles) clamp tight and cure at 110 F for 3 hr. Remove from mold, trim flash, and buff. Finished dials should be like those at left. Note epoxy-metal core and cavity, with optional embedment of hex nuts to take jackscrews.



Switchbox look-alikes . . . show how precisely cast plastics can simulate a component. One of these boxes is production-molded in phenolic, the other is its prototype cast in epoxy. Can you tell which is which? (Model is at left.)

LIST OF RECOMMENDED MATERIALS

Item	Designation	Source
Modeling clay	Hard and soft types	Chevant Mfg. C, Jersey City, NJ
Plaster	Industrial White Hydrocal	US Gypsum (any building supply)
Epoxy resin	Stycast 2651 (filled) with hardener No. 9: (1:20 by wt)	Emerson & Cummings Inc, Canton, Ohio
	Castiplast 17 (filled), or Castiplast 11 (unfilled) with hardener No. 1: (1:12 by wt for No. 17) (1:6 by wt for No. 11)	Nat'l Engineering Products Co, Wash, DC
Pigment (for Castiplast)	Epoxy paste colors	Ferro Corp, Cleveland
Mold release	Paste wax	Butcher's, or Staples' (any hardware)
Shellac & thinner	White	Any hardware
Inexpensive balance, and weight set	Triple beam, #3450 1—500 gm, #9125	Central Scientific Co, Chicago
Marble work—slab	Hard, nonporous, smooth	Any rummage store
Paper mixing cups	Non-wax type	Any hardware
Plaster mixing bowls	Polyethylene	Any hardware
Mixing—spatulas and sculpture tools	Assorted sizes	Alexanders Sculpture Supply, New York

plaster mold. Epoxy will give best finish for 2 to 20 parts of considerable detail; use metal or Lucite molds only when up to 100 complex parts are needed.

4—RESIN SELECTION: Use Castiplast (natural color: beige) for molds and all colored parts subject to less than 200 F; Stycast (natural color: black) for molds and all high-temperature parts (up to 350 F). High temperatures require optimum properties, obtained by long cure. When selecting other available epoxies, look for: minimum exotherm, viscosity, shrinkage, setting time and cure temperature (so mold and release materials won't break down); maximum pot life, colorability, service temperature.

5—MOLD RELEASE: Always use a parting agent when casting plaster or epoxy against anything but clay. For plaster against plaster, the plaster pattern should be sealed and lubricated (wax or vaseline) so that water will not be drawn from the fresh plaster before it sets. For epoxy against plaster, plaster should be thoroughly dry—any moisture will prevent perfect cure. Epoxy cast against clay will not completely cure at the parting surface, requiring acetone cleaning.

6—MIXING RESIN: When mixing hardener with resin, stir carefully to avoid bubbles, and thoroughly to prevent uncured streaks in part. Remember that catalyzed resin has only 10-15 minutes' pot life, so plan each step before adding hardener.

7—COLORS: Always mix in color paste before adding hardener. Proportions of paste to resin for a given color given by manufacturer are invariably low, up to 20% color being required occasionally for maximum brilliance. Omit color weight when weighing ingredients.

8—SHRINKAGE: Use filled materials for minimum shrinkage. Unfilled epoxies shrink more, but polish better if mold surface requires that casting be hand finished.

9—INTERNAL HEATING: Cure parts with heavy (over ¼ in.) sections at lower temperatures (70-80 F vs 90-110 F) to avoid excessive shrinkage and warping. Exothermic heating will provide the cure.

10—CLEANLINESS: Clean utensils after each job; polyethylene bowls are useful for plaster and large mixes of resin. Use paper cups where possible. Follow resin manufacturers handling instructions; epoxy systems have toxic and flammable ingredients.

EDITOR'S NOTE: For other articles in this continuing series on models and similitude, see the following:

Structural Models—They Preview Stress and Strain, Oct 26 '59, p 55. Three-part report tells how to design structural models, materials to use, and how to test.

Clay Models Will Shape Your Ideas, Oct 12 '59, p 68. A quick, inexpensive way to get a clear image of the proposed component.

Fluid-flow Models Predict Design Performance, Aug 17 '59, p 64. Functional models that predict behavior of liquids flowing through or around obstructions.

Build a Model Shop, Oct 13 '58, p 74. A survey of several "captive" model shops shows what will be needed and how to organize the shops.

Model Shop Saves Development Time, Oct 6 '58, p 32. Why craftsmen and special tools devoted exclusively to model-building can save time and money.

Models Show How, Sep 16 '57, p 99. Full-color photos of typical models that help designers visualize a product.

Use of Mockups in Design, Oct '56, p 183. How wood and cardboard counterparts can give a layout three dimensions.

Three-dimensional Photoelasticity, July '57. Cast epoxy models are key to more effective use of a powerful stress analysis tool.

For readers who want more information on epoxies as engineering materials, see these articles:

Three New Epoxies Join the Pre-preg Laminates, Aug 31 '59, p 38—resins series combines good high-temperteure performance with long shelf life.

Selecting Plastic Laminates for Punching, Feb 2 '59, p 57. Ready-reference chart relates punching ease of various laminates to electrical and mechanical properties.

Epoxy Castings, June '57, p 135. Characteristics of casting resins and how epoxies fit in; how to design large castings as low-cost alternative to metal for low-volume applications.

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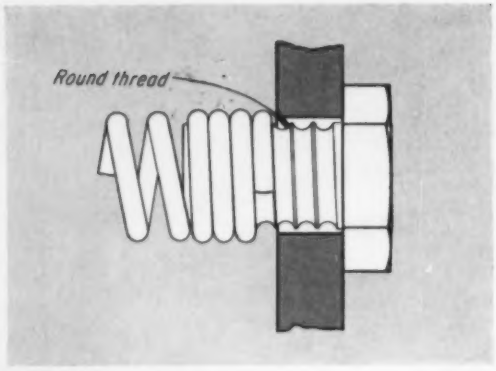
29 Ways to

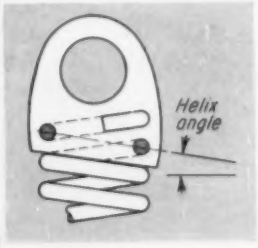
EXTENSION SPRINGS

Four pages of ingenious attachments for extension, compression and torsion springs.

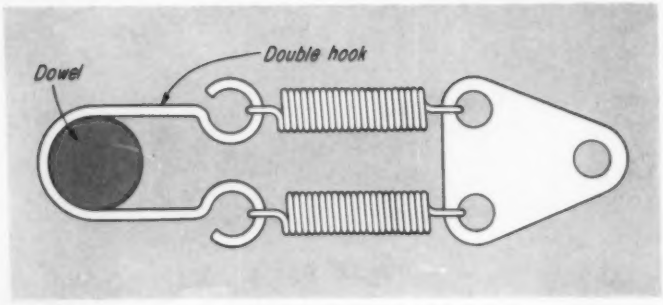
FEDERICO STRASSER, *Mankowitz & Strasser*
Santiago, Chile



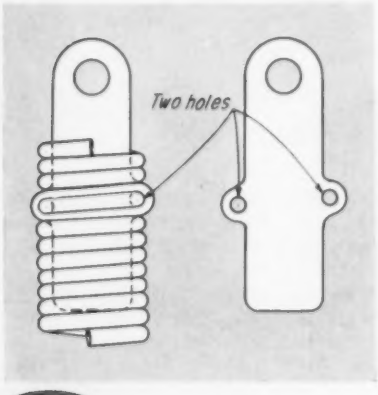
1
Screw fits into spring end.



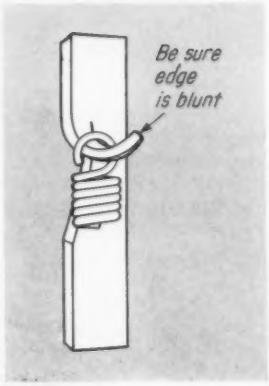
2
Tab with 3 holes engages 1½ spring-coils.



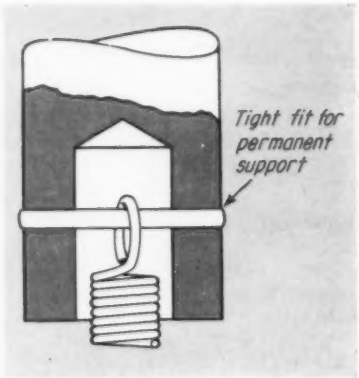
3
Twin-spring setup includes double hook and triangular tab.



4
Long tab with 2 holes in midsection provides ample adjustment.

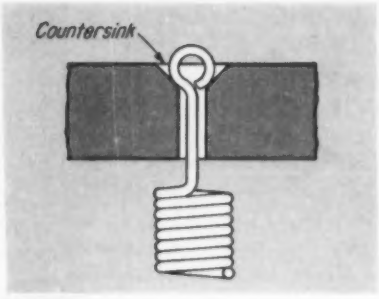


5
Sheetmetal, slit and formed, suspends spring.



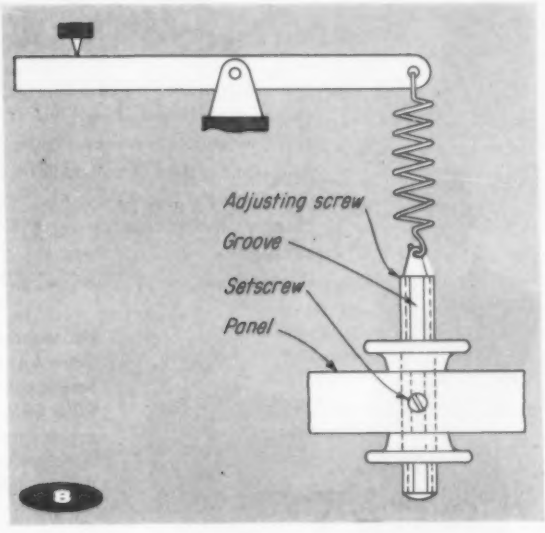
6
Cross-pin holds spring deep in hole.

Fasten Springs



7

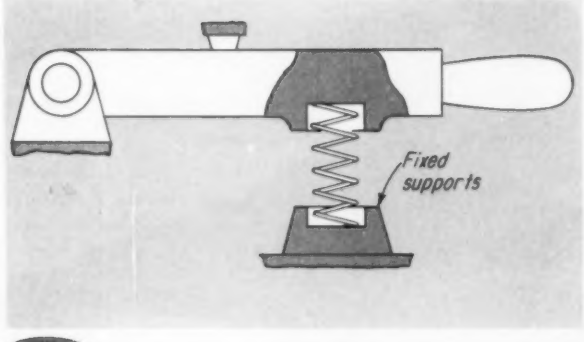
Countersunk hole leaves spring free to turn.



8

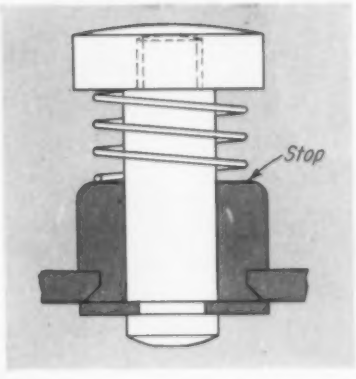
Tension adjustment requires nonrotating screw.

COMPRESSION SPRINGS



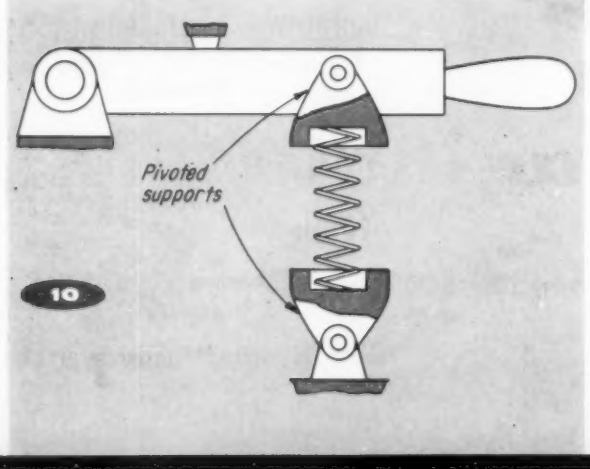
9

Unsupported spring-body must have somewhat more resistance to buckling in fixed supports (9) than pivoted ones (10).

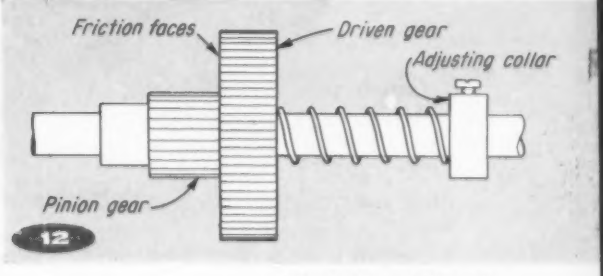


11

Supported springs are exemplified in push button (11) and friction clutch (12).



10



12

(CONTINUED ON PAGE 69)

the SAGINAW b/b SCREW helps

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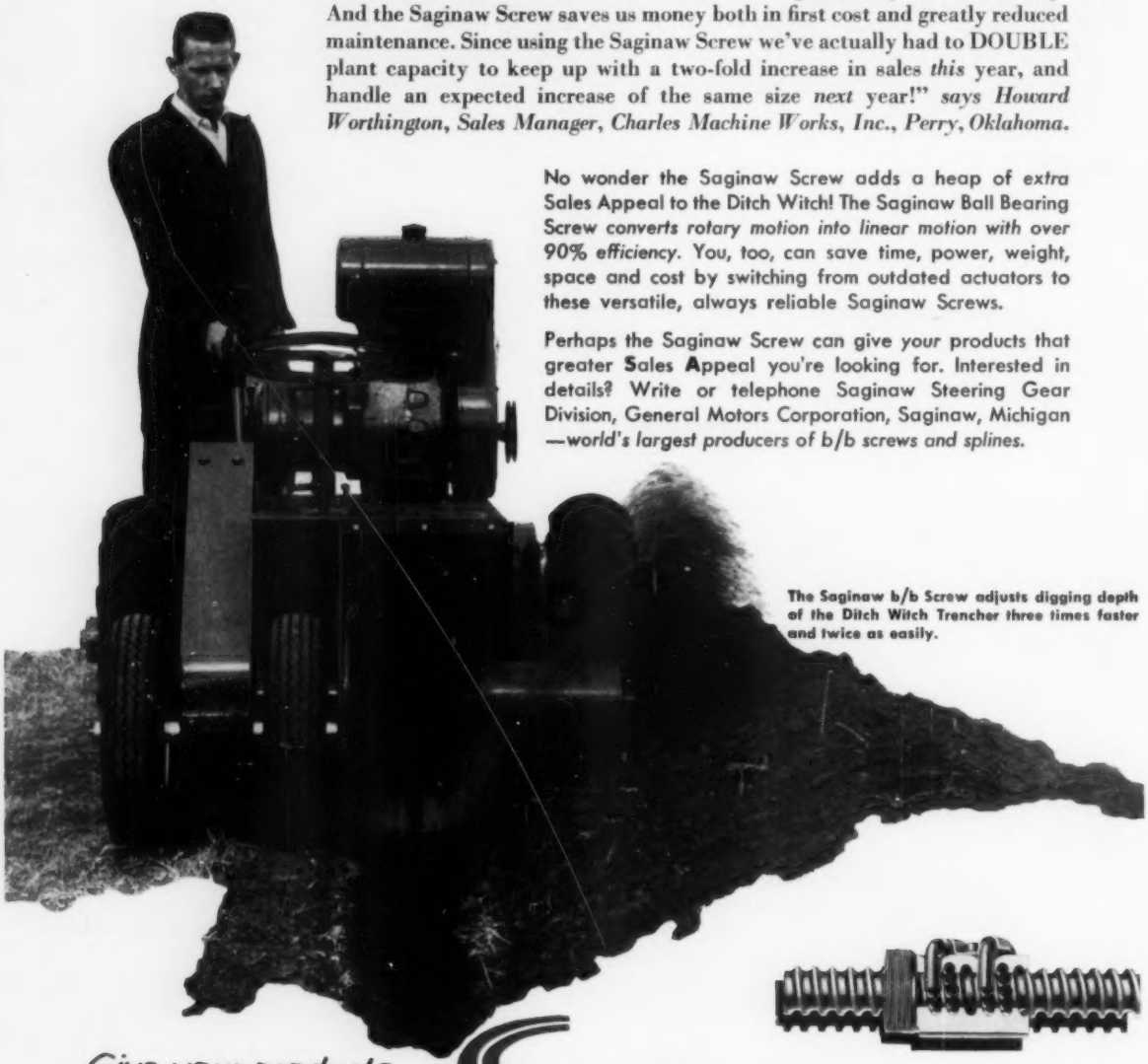
"We've replaced an acme screw with a Saginaw Ball Bearing Screw to enable the digging boom of our Ditch Witch Trench Digging machine to be raised and lowered three times faster. It makes the operator's job twice as easy. And the Saginaw Screw saves us money both in first cost and greatly reduced maintenance. Since using the Saginaw Screw we've actually had to DOUBLE plant capacity to keep up with a two-fold increase in sales *this* year, and handle an expected increase of the same size *next* year!" *says Howard Worthington, Sales Manager, Charles Machine Works, Inc., Perry, Oklahoma.*

No wonder the Saginaw Screw adds a heap of *extra* Sales Appeal to the Ditch Witch! The Saginaw Ball Bearing Screw *converts rotary motion into linear motion with over 90% efficiency.* You, too, can save time, power, weight, space and cost by switching from outdated actuators to these versatile, always reliable Saginaw Screws.

Perhaps the Saginaw Screw can give *your* products that greater **S**ales **A**ppeal you're looking for. Interested in details? Write or telephone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan —*world's largest producers of b/b screws and splines.*



The Saginaw b/b Screw adjusts digging depth of the Ditch Witch Trencher three times faster and twice as easily.

Give your products NEW SALES APPEAL... switch to the **Saginaw**

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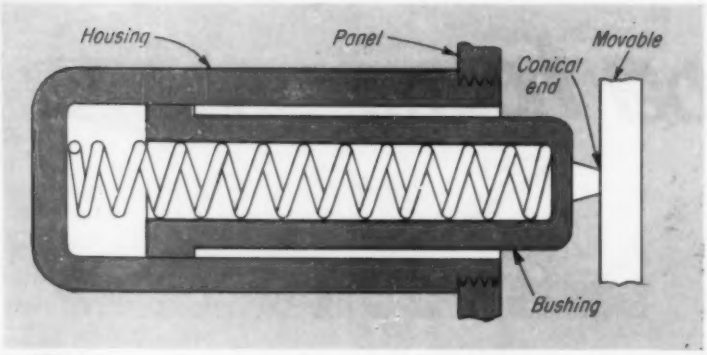
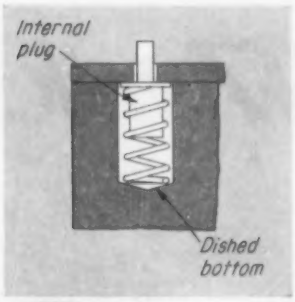
WORLD'S MOST EFFICIENT ACTUATION DEVICE



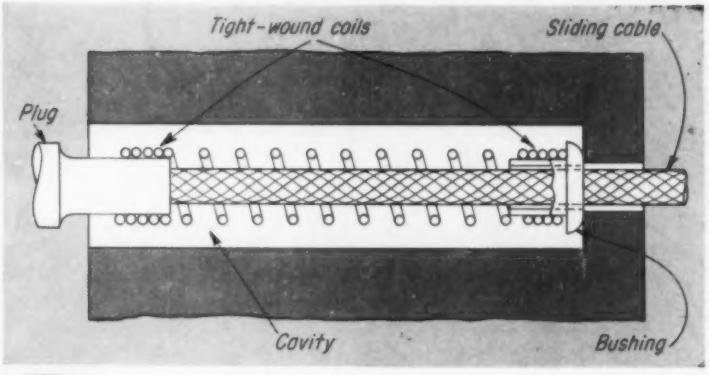
13

Concealed spring is supported externally by closed-end bushing, which also determines amount of compression.



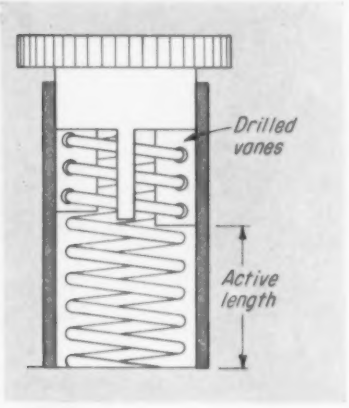
14

Double guidance is exemplified by hole-bottom that centers spring end, and internal plug that supports spring body.



15

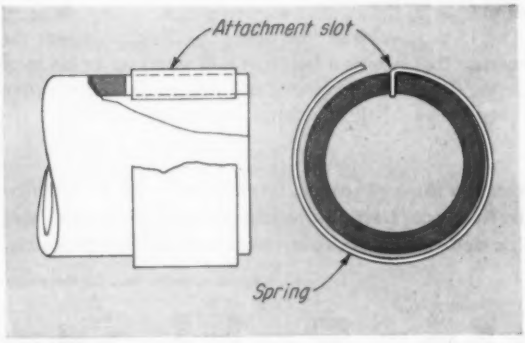
Tight-wound end-coils hold switchboard plug bushing—spring absorbs shock when weighted cable snaps entire assembly back into cavity after operator disconnects plug at end of message.



16

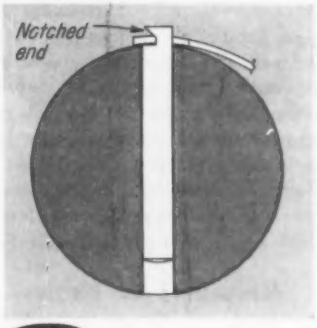
Adjustment vanes have holes that match spring pitch. Spring coils threaded through vanes become inactive, thus varying effective spring length.

FLAT TORSION-SPRINGS



17

Saw-cut slot retains spring positively if slot end is peened over or otherwise closed.



18

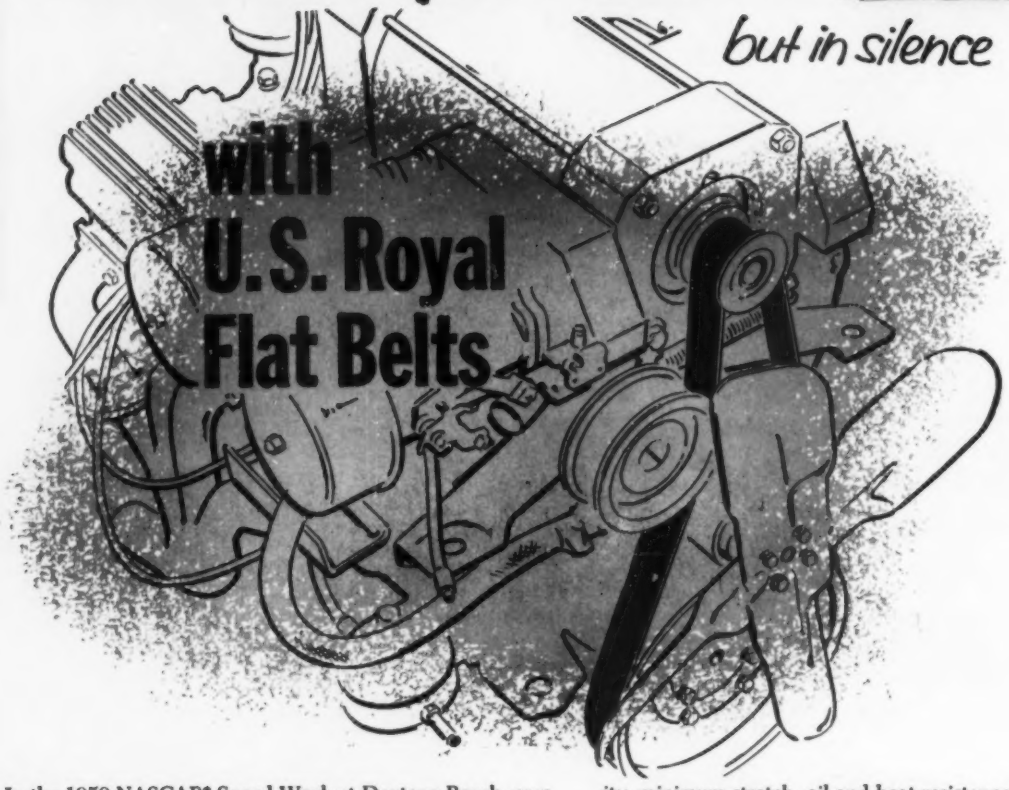
Notched dowel provides hook for hole in spring end.

(CONTINUED ON PAGE 71)

ROYAL FLAT BELTS

147 miles per hour...

but in silence



In the 1959 NASCAR* Speed Week at Daytona Beach, cars with Latham Axial Flow Superchargers swept the field for the second straight year. Top speed for one of these cars was 147 m.p.h.

Every Latham Supercharger is equipped with a U.S. Royal 1½"-wide heavy duty drive flat belt. This is the main reason why the compressor runs so silently, so dependably. This "U. S." belt effectively handles the high-speed, high-load requirements of this drive with no stress or strain. In delivering smooth, quick power to the compressor, it easily resists destructive heat build-up. The performance of this belt on such a gruelling assignment demonstrates how effective this belt can be on tough drives on all types of machinery.

U. S. Royal Flat Belts are made with special constructions to service all types of drive conditions. They are furnished in combinations of high tensile strength, maximum flexibility, minimum stretch, oil and heat resistance, static conductivity with special covers. In most combinations the length is stable or shrinkless.

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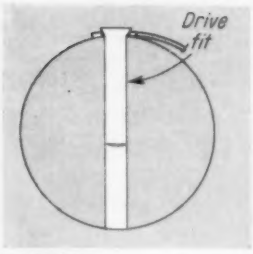
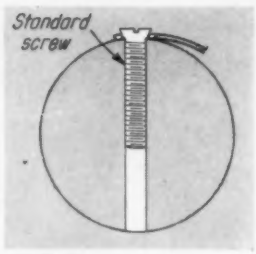
29 Ways to Fasten Springs (CONTINUED)

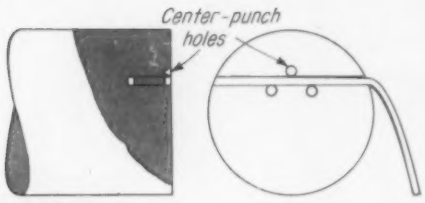


19



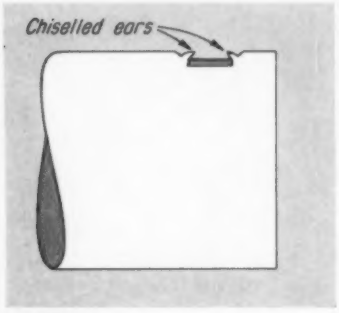
20

Headed drive-pin through spring hole makes disassembly difficult (19). Standard screw (20) eases disassembly.



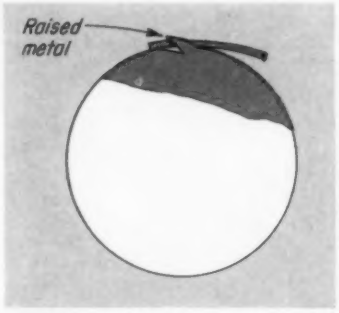
21

Chordal shot in shaft is closed tight by displacing metal with center punch for permanent spring retention.



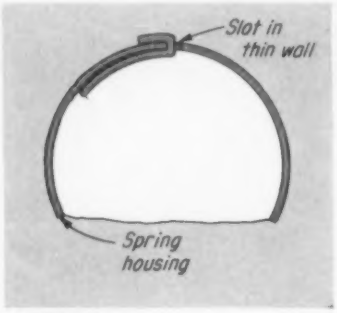
22

Chordal groove holds spring when ears are formed by chiselling or staking after assembly.



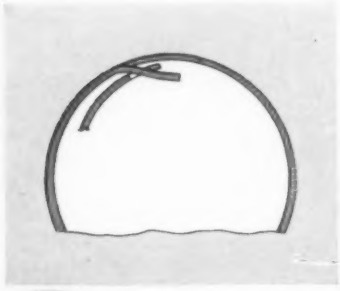
23

Raised metal, produced by staking, provides low-cost yet firm hook on shaft.



24

Slotted spring-housing is simple, but spring-end can be dangerous if housing revolves and is unprotected.

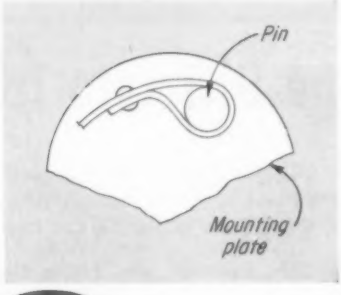


25

Lanced tab avoids hazard of external spring-end but dirt can enter housing.

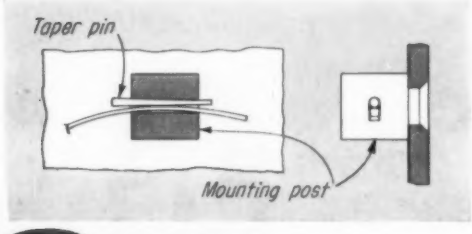
26

Shoulder rivet provides dustproof fastening.



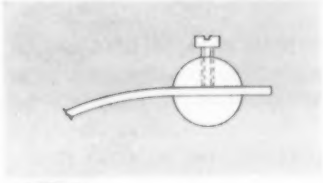
27

Mounting pin on plate may be plain, or headed—for more positive spring retention.



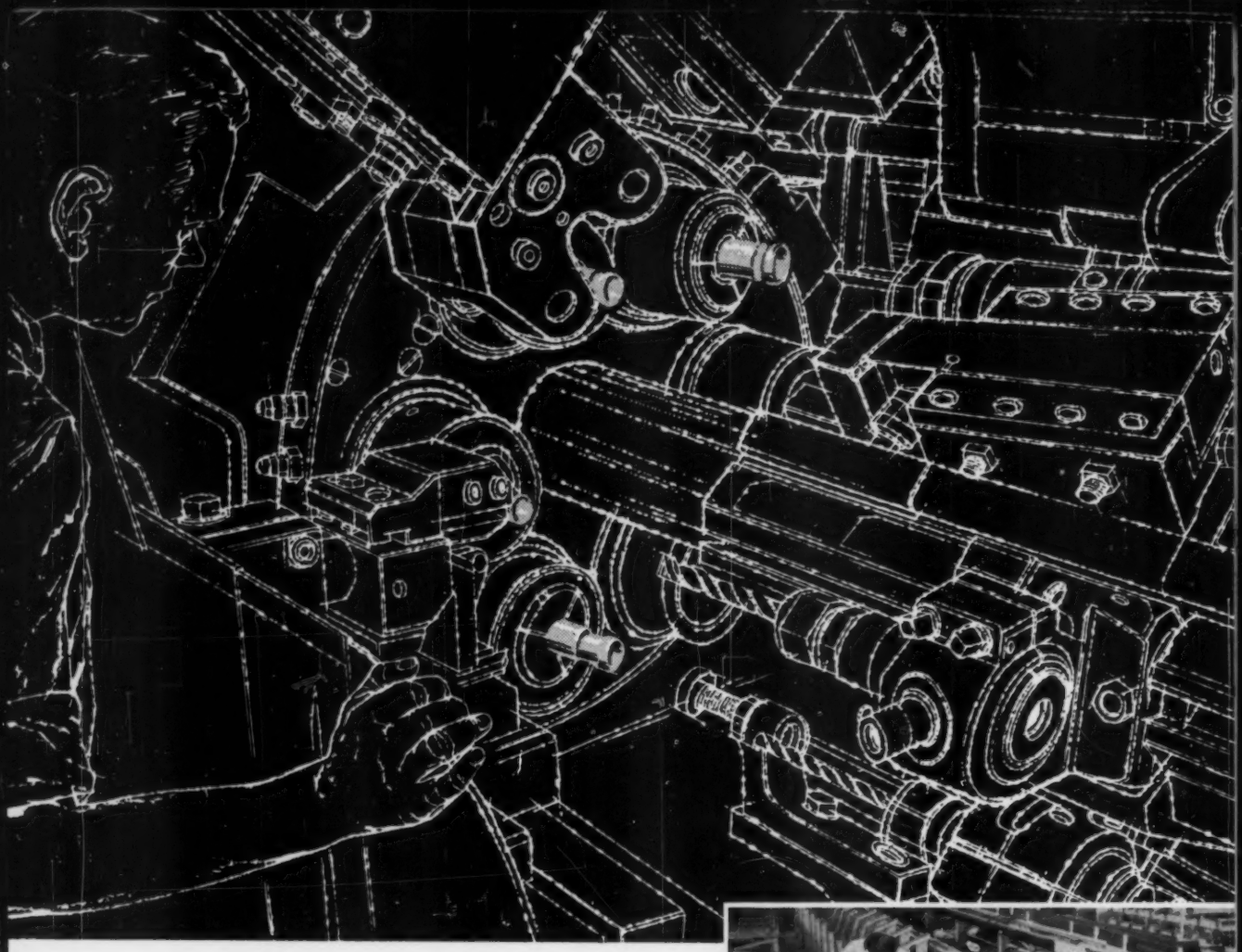
28

Taper pin allows end adjustment of precision, low-torque springs.



29

Setscrew and slotted post also provides adjustment feature but may be inefficient if spring-end becomes dimpled.



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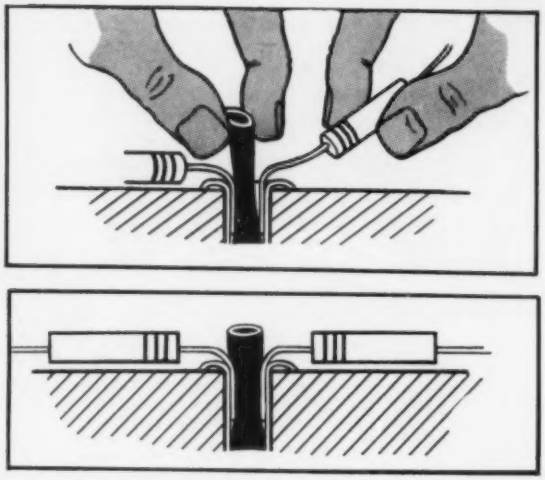
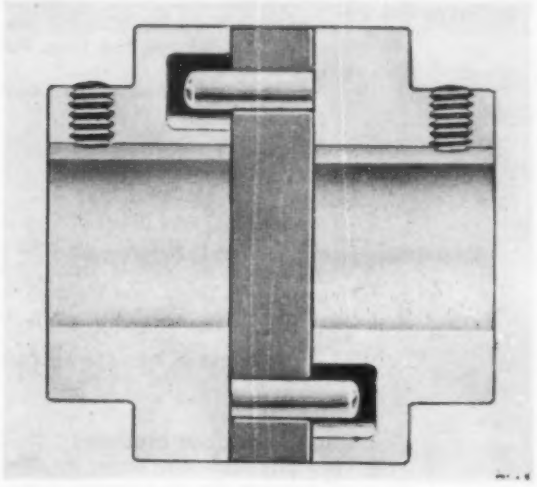
SIGNIFICANT COMPONENTS MATERIALS PROCESSES



Solderless connections . . .

between wiring and component leads consist of standard eyelets and rubber tubing. Tubing is inserted in eyelet, pulled upward so that it stretches enough to allow wires also to be slipped into hole. When released, tubing grips leads, pressing them firmly against eyelet surfaces, establishing a contact said to be essentially of zero resistance. Rubber tends to shape itself around each wire, regardless of size or shape. Technique is available under license. Estimated material and labor cost per junction, less than 5¢. **Plastic Associates, 185 Mountain Road, Laguna Beach, Calif.**

Circle 300 on Reader Service Card



Flexible coupling . . .

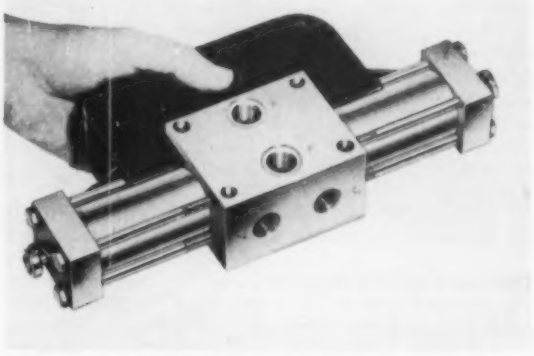
consists of two flanges with steel drive pins which are molded into a laminated woven nylon and elastomer disk. Designed to withstand operating temperatures to 700 F, horsepower ratings range from 0.25 hp to 7.12 hp at 100 rpm, 2.23 to 61 hp at 3000 rpm, depending on bore size. Bore sizes $\frac{7}{8}$ to $3\frac{1}{8}$ in. are available, ranging in list price from $1.60 to $20; available from stock in regular bore sizes. **Van Gelder Mfg, Inc, 3654 Grand Ave, Oakland 10, Calif.**

Circle 301 on Reader Service Card

Resin-bonded quartz sheet . . .

consists of heat-resistant resin impregnated with finely divided particles of fused quartz, together with a small percentage of glass or other fibers. Melting point of the quartz is 3100 F, and resulting liquid is said to be extremely viscous, so that it is not washed off but tends to act as an insulator for structural material beneath. Available in sheet form in thicknesses of 0.010 to 0.020 in., 36 in. wide. Roll length is normally 30 to 40 yd. Price is in the neighborhood of $2.00 per lb; delivery within a week of order. **Cordo Chemical Corp, Norwalk, Conn.**

Circle 302 on Reader Service Card



Solenoid valve without inrush . . .

current is said not to heat up even with cycling as frequent as 60 cpm. Valve body is aluminum, with heat-treated steel spools and sleeves, and is rated at 3000 psi. Available for 110 or 220-v operation, using same coils for any frequency of 25 to 60 cps. Has two solenoids, weighs 5 lb, and is designed for stacking. Available at present in $\frac{3}{8}$ in. pipe size only. Delivery, 8 to 10 wk. **Waterman Hydraulics Corp, 725 Custer Ave, Evanston, Ill.**

Circle 303 on Reader Service Card

Formable high density metal . . .

has been cold rolled to 52% reduction, with resulting ultimate tensile strength of 195,000 psi, yield strength of 190,000. Modulus of elasticity was 54 x 10^6 and elongation, 0.5% per in. The alloy is available in rolled sheets or slabs 0.010 to 0.250 in. thick, up to 8 in. wide, to 40 in. long. Swaged rod is made 0.062 to 0.375 in. dia, in lengths of 8 to 36 in. About $8 to 12.50 per lb. Delivery, 4-5 wk. **Mallory Metallurgical Co, Div P. R. Mallory & Co, Inc, 3029 E Washington St, Indianapolis 6.**

Circle 304 on Reader Service Card

. . . CONTINUED ON PAGE 74

←CIRCLE 72 ON READER SERVICE CARD

Hydraulic deceleration valve . . .

has throttle that permits external adjustment of back pressure to provide desired deceleration rate by altering internal port area. Rated for 5 to 25 gpm, valve can be used for applications to 60 gpm without malfunction. Max recommended operating pressure is 3000 psi. Price of ¾-in. size $79.50 for threaded connections; $89.50 for gasket mounted unit. Delivery, 6-8 wk. **Vickers Inc, div Sperry Rand Corp, Detroit 32.**

Circle 305 on Reader Service Card

Microminiature lamp . . .

small enough to pass through needle's eye measures 0.125 x 0.040 in. Light output of this incandescent lamp is 100 millilumens at 1.5 v input. Available after Jan. 1 '60. **Sylvania Electric Products Inc, sub General Telephone and Electronics, 730 Third Ave, New York 17.**

Circle 306 on Reader Service Card

Adhesive for non-structural . . .

applications is based on a hot melt type of synthetic resin and is recommended for bonding mylar, polyethylene, glass and other slick-surface, bond-resistant materials. Service temperature range is 120 F to 200 F, although resin will withstand short periods at 250 F. About $1.66 per lb. Delivery, 7 days. **Raybestos-Manhattan, Inc, Bridgeport, Conn.**

Circle 307 on Reader Service Card

Ball screw has bypass . . .

channel that unloads each ball as it completes one revolution circuit. Said to provide faster unloading and reduce dynamic forces between balls. Pitch accuracy is 0.0002 in. per ft. Shaft diameters from ¼ to 5 in. can be made in lengths up to 40 ft. Hardness of screw shaft, balls and nut is 60 Rc min. Delivery, 3-4 months. **Scully-Jones & Co, 1917 S Rockwell St, Chicago 8.**

Circle 308 on Reader Service Card

Electron beam machining . . .

can cut round or complexly shaped holes as small as 40 microns across (tolerance, ±5 microns) in such materials as tungsten, diamond, carbides, steel, brass, aluminum. Work is accomplished by beam of electrons produced by heated tungsten filament, accelerating to potential of 25,000 to 110,000 v and focused on work by electronic lens. Material to be removed is volatilized, and undesirable effects in adjacent areas are minimized by pulsing beam on and off; heat-affected zones are only a few microns wide. Tooling is not required, since dimensions of holes are programmed into machine. This company has one German-built licensed machine available; cost is $65 per hour for repetitive work, over and above setup charges. **L R Industries Inc, 50 MacQuesten Pkwy S, Mt Vernon, NY.**

Circle 309 on Reader Service Card

Steel for forging or machining

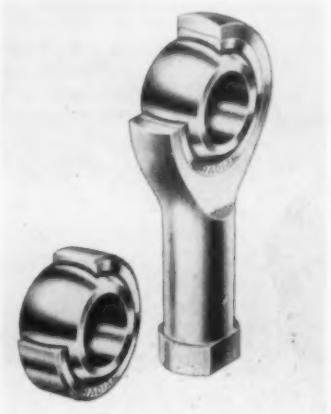
can be heat treated to develop tensile strengths of 280,000 to 300,000 psi. Alloy is based on 0.75-1.00 Mn, 0.50-0.80 Si, 0.60 to 0.90 Ni, 0.80 to 1.05 Cr. Sold in either hot-rolled or annealed condition in full range of bar sizes and as billets and blooms up to 15¾ in. square. **United States Steel Corp, 525 William Penn Pl, Pittsburgh 30.**

Circle 310 on Reader Service Card

Aluminum louver . . .

is made in six sizes ranging from 1 to 4 in. dia. Grille openings are smaller than regular screening. **Midget Louver Co., 6 Wall St, Norwalk, Conn.**

Circle 311 on Reader Service Card



Self-aligning spherical bearing . . .

has Teflon-coated outer raceway, is said to be self-lubricating and suitable for low surface speeds, high unit loads or applications subject to high dynamic loading. Available with ⅜-in. bore. **Radial Bearing Corp, Taylor St, Danbury, Conn.**

Circle 312 on Reader Service Card

Full-port solenoid valve . . .

is normally closed and is designed for pressure ratings to 500 psi, where fluid temperature does not exceed 400 F. Solenoid has Class H insulation and can be replaced without removing valve from line. **Magnatrol Valve Corp, Hawthorne, N J.**

Circle 313 on Reader Service Card

3-way exhaust valves . . .

have brass bar stock bodies with ¼-in. connections. For air, gas, water or light hydraulic oil to 160 psi, depending on type of solenoid used. Three forms of operation are available: normally closed, normally open, and interchangeable. In any voltage up to 550 v, 60 cps. **Automatic Switch Co, Florham Park, N J.**

Circle 314 on Reader Service Card

Self-locking washer-nut . . .

available in steel, aluminum, silicon bronze, stainless steel, plated to specifications, in sizes No. 4 through ⅜ in. Samples available. **Jacobson Nut Corp, Box 177, Kenilworth, NJ.**

Circle 315 on Reader Service Card

Heavy duty bevel gear boxes . . .

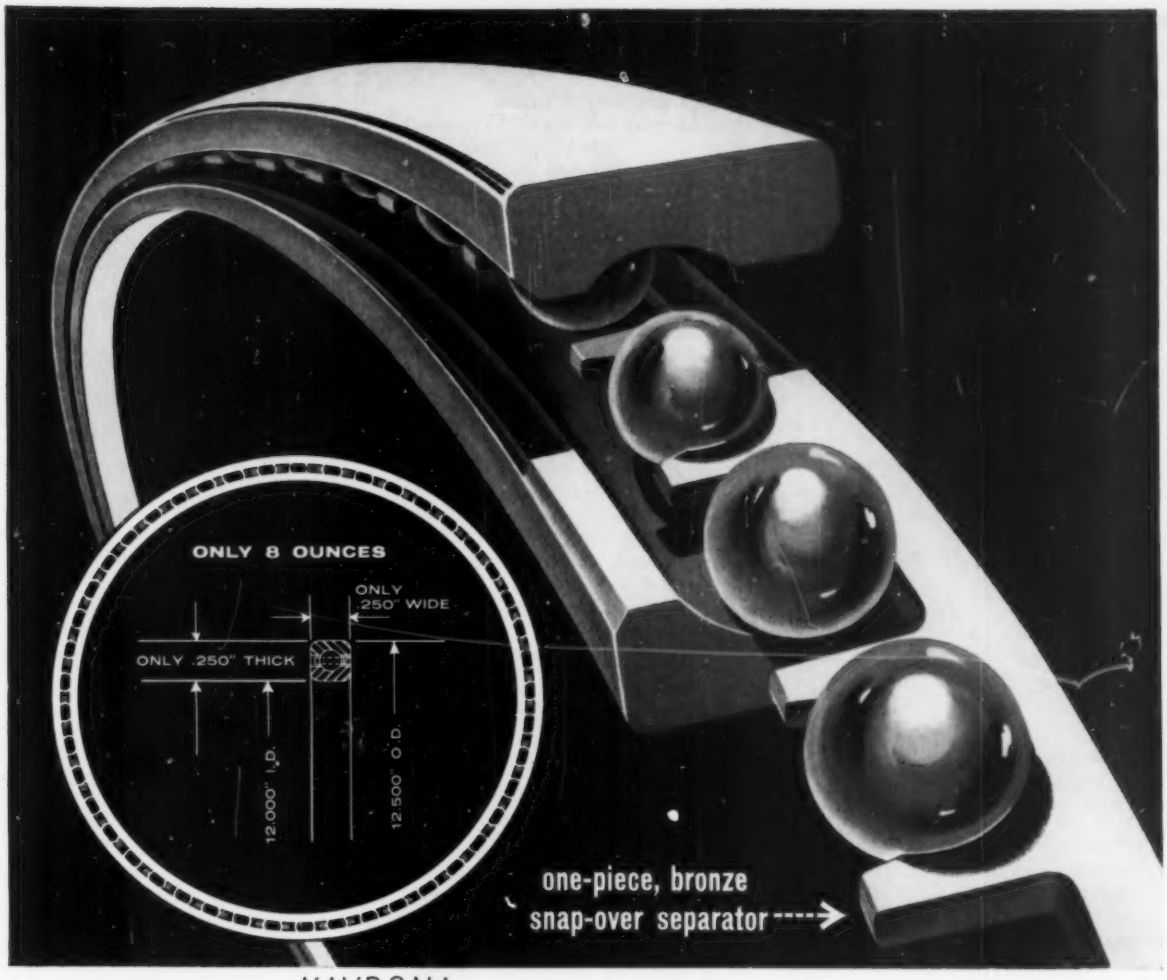
are available from stock in ratios of 1:1 to 3:1; shaft sizes ⅛ to ¼ in. dia; ball bearing or oilless bearings; variable inputs and outputs. Price ranges from $30 to $50. **Pic Design Corp, 477 Atlantic Ave, E Rockaway, N Y.**

Circle 316 on Reader Service Card

Digital readout modules . . .

1 1/16 x 1 7/8 x 1¾ in. deep display any numeral from zero through 9, through electromagnetic indicating segments in any desired combination by low-power dc signal. Both momentary and memory units are available. Operation is by any dc volt-

. . . CONTINUED ON PAGE 76



News from KAYDON!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%

90 sizes — 4" to 12" bore — 1/4" to 1" width and cross-section

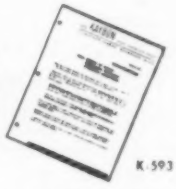
Drastic price reductions — on Kaydon new type "CP" Reali-Slim bearings! Volume production and new bronze snap-over separator permit price reductions from 33 to 76%, depending on size.

Save on bearing cross-section and weight — Reali-Slim is the world's thinnest radial ball bearing. Many sizes of type "CP" are less than 15% of the weight, 34% of the width and cross-section of comparable, extra-light bearings.

Type "CP" with new one-piece, bronze snap-over separator — Major applications include machine tools; farm, textile and paper machinery; printing presses; pumps and gear boxes; missiles, aircraft and radar; gun turrets and dozens of related installations.

Kaydon bearing engineers are prepared to give you valuable help with technical thin-section bearing applications.

New "CP" Reali-Slim bearing bulletin includes prices — gives you full details on these 90 sizes of Reali-Slim bearings with Conrad deep-groove, ball-radial construction. Write for your free copy today.



K-593

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . .
Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings • 4-Point Contact Ball Bearings

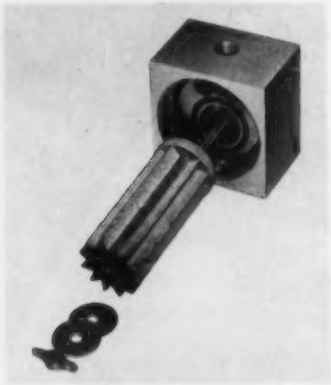
age from 1 to 30 v; response time less than 0.1 sec. **Allard Instrument Corp, 146 E 2nd St, Mineola, N Y.**

Circle 317 on Reader Service Card

Hydraulic pump motor . . .

in Nema frame sizes 182 through 215 is available in dripproof, enclosed or explosionproof construction. Available in all ratings 1 through 5 hp. **General Electric Co, Schenectady 5.**

Circle 318 on Reader Service Card



Hydraulic fluid filter . . .

has reinforced sintered bronze 40-micron element. Rated for 1000 psi, available for ⅜ and ½ in. pipe connections. Accumulation of foreign matter sufficient to cause as much as 400 psi pressure drop is said not to cause element to disintegrate; merely cracks while retaining trapped particles and element pieces. **GPE Controls, Inc, 240 E Ontario St, Chicago 11.**

Circle 319 on Reader Service Card

Nut with free-turning washer . . .

is said to weigh ½ to ⅓ as much as AN 365, NAS679, MS20365 fasteners of identical size without washers. For up to 800 F, meets MIL-N-25027 requirements. Thread sizes: 2-56 through 10-32. **Kaynar Mfg Co, Inc, Box 2001, Terminal Annex, Los Angeles 54.**

Circle 320 on Reader Service Card

Vibration monitor . . .

senses vibration levels in machinery and motors, automatically shutting them down or sounding alarm. Scanning unit can take up to 10 pickups, which are monitored in preset sequence. Trigger unit amplifies signals and feeds them to control circuit. **Kahn & Co, P O Box 516, Hartford 1, Conn.**

Circle 321 on Reader Service Card

Nickel plating process . . .

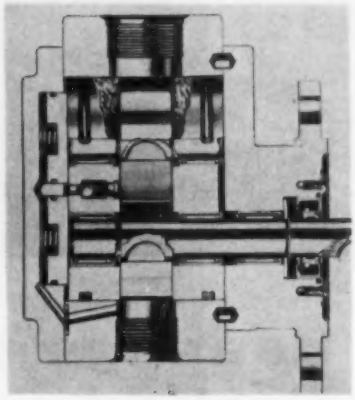
yields deposits said to be exceptionally bright at both high and low density areas and possessing unusual ability to level out scratches. High tolerance to inorganic impurities is reported and bath is amenable to continuous carbon treatment for organic contamination. Conversion of existing equipment is easy, according to manufacturer. **Hanson-Van Winkle-Munning Co, Church St, Matawan, N J.**

Circle 322 on Reader Service Card

Gage for high pressure . . .

lines where small differentials are to be measured is suitable for either gas or liquid service. Accurate to 0.5% full scale, and sensitive to pressure change of 1:1000. Available for two standard ranges: full scale of 2 psi differential at line pressures to 50 psi; 5, 10 or 20 psi differential to 300 psi. **Wallace & Tiernan Inc, Belleville 9, N J.**

Circle 323 on Reader Service Card



Gear pump for 3000 psi . . .

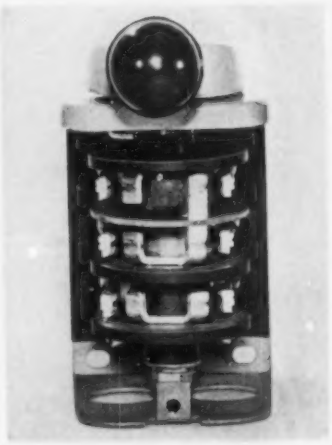
constant pressure and 4500 psi intermittent is said to deliver uniform flow regardless of variations in viscosity or load and is available with capacities of 5, 10, 15 or 30 gpm. Needle bearings are contained in one-piece bearing blocks to minimize gear misalignment under load. Rear bearing block is forced against gear faces by hydraulically actuated pistons for wear compensation and minimum end clearance. **Superior Pipe Specialties Co, 15201 St Clair Ave, Cleveland 10.**

Circle 324 on Reader Service Card

Fractional-watt dc motor . . .

has neither revolving windings nor sliding commutator. Integral reduction gear assembly provides range of output speeds. Can be supplied for operation between −50 F and 160 F. Designed for unidirectional start, output torque to 40 in.-oz at 1 rpm. Available wound for 3, 6, 12, or 24 v dc. **Brailsford & Co, Inc, 670 Milton Road, Rye, N Y.**

Circle 325 on Reader Service Card



Drum switch for single-speed . . .

electric motors up to 2 hp provides starting, stopping and reversing. Shipped as maintained contact unit, easily changeable to momentary contact. Measures 4⅝ x 2⅞ x 4⅛ in. deep. **General Electric Co, Schenectady 5.**

Circle 326 on Reader Service Card

High speed hydraulic pump . . .

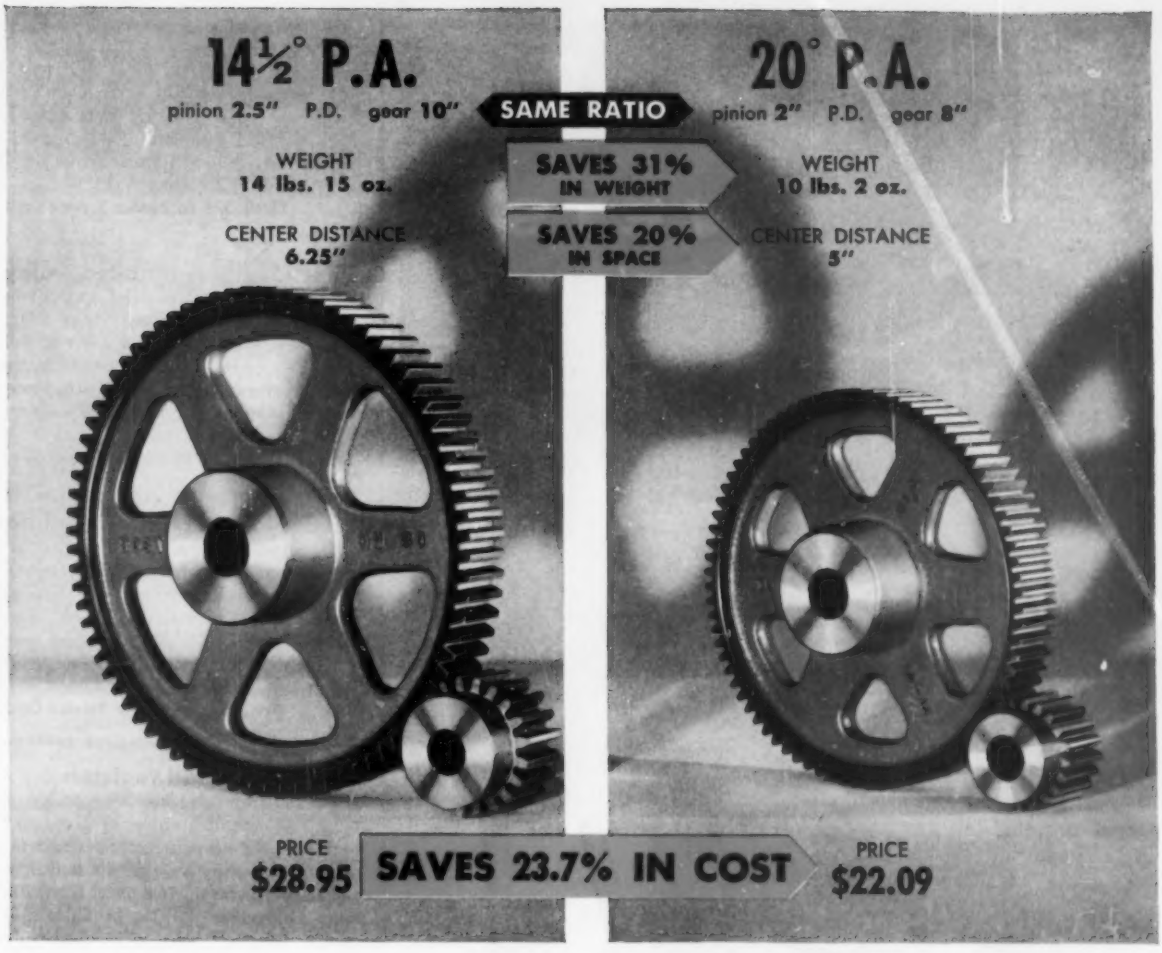
for continuous operation at speeds to 50,000 rpm and discharge pressures to 3000 psi are available in capacities varying from 0.2 to 11.5 gpm. **Parker Aircraft Co, 5827 W Century Blvd, Los Angeles 45.**

Circle 327 on Reader Service Card

Calculator for production . . .

determines most economical runs by comparing competitive tooling quotations with

. . . CONTINUED ON PAGE 78



Both meet the job specifications — but

one of these gear sets costs you 23% less

NOW...567 STANDARD SIZES OF BOSTON 20° P.A. GEARS *From Stock*

SPUR Steel and Iron 20 to 4 P.
Fine Pitch Brass 64, 48, 32, and 24 P.

MITER Cast Iron 8 to 2½ P. Steel 48 to 4 P.
Fine Pitch Brass 48, 32, and 24 P.

BEVEL Steel and Iron 20 to 3 P.
Fine Pitch Brass 48, 32, and 24 P.

For complete listings see the BOSTON GEAR CATALOG No. 57

Every engineer knows the quiet-running efficiency and high strength of the 20° Pressure Angle tooth form. For most installations, the 20° P. A. Gear that meets specifications saves an average of 20% in space, weight, and cost over the comparable 14½° P. A. Gear required.

Now, the types and sizes of 20° P. A. Gears you need to make these big savings in your assemblies are available, anywhere in industrial U.S.A. and Canada, FROM STOCK at over 100 conveniently located BOSTON GEAR Distributors.

Your local Distributor's factory-trained gear specialist is at your service. Get details. Start *making* the savings you've been missing. Boston Gear Works, 71 Hayward St., Quincy, Mass.

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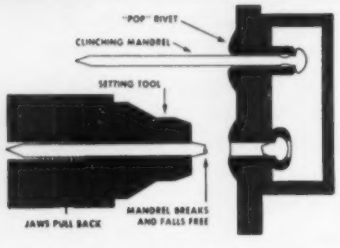
— STANDARDIZATION PAYS —

"POP"
RIVETS

Assemble finely finished wood chair panels, enameled or painted metal sheets, "POP" Rivets save the surface. Setting tools can't slip. Burrs on fastener head and countersinking are eliminated.



HOW THEY WORK — "POP" Rivets are assembled on a precision high-tensile mandrel. Mandrel head is drawn into the reverse side of rivet with a setting tool. Mandrel head breaks off under tension clinching the rivet. Work is squeezed by compression — controlled radial expansion. Setting tools from $18 to $300.

"POP" Rivets set by compression without the turning action which tears the surface finish allowing corrosion to start. Fasten sheets as thin as .020 dead soft aluminum or 24 gauge steel without distortion. Use thinner materials without creating a fastener problem.

"POP" Rivets install and set from same side. Get this design advantage for your product. Set up to 1,000 an hour with unskilled help. 50% savings in installed fastener costs suggest your immediate investigation.

"POP" RIVET DIVISION
UNITED SHOE MACHINERY CORPORATION
RIVER ROAD, SHELTON, CONN.
REgent 5-3391

UNITED
"POP"
RIVETS

cost per piece or part. Will indicate break-even point between two methods in relation to tool amortization. Price 50¢ each. **Grayhill Moldtronics, Inc, 561 Hillgrove Ave, La Grange, Ill.**

Circle 328 on Reader Service Card

Directionally controlled relay

for reverse-power, three-phase applications is rated 120 v line to line, 5 amp. Main contacts can close 30 amp at 250 v dc and carry this current for sufficient time to trip a circuit breaker. **Westinghouse Electric Corp, PO Box 2099, Pittsburgh 30.**

Circle 329 on Reader Service Card

Carbide-impregnated graphite

has nonporous, hard carbide surface, resists corrosion, operates at higher temperatures than resin bonded graphite. Can be machined only with diamond tools. Specific gravity is 1.8 to 1.9, compared with 1.6 for resin impregnated graphite. **Falls Industries, Aurora Rd, Solon, Ohio.**

Circle 330 on Reader Service Card

Injection-molded registers . . .

grilles and curved blade diffusers, made of nylon, are noncombustible, heat resistant to 300 F, distortion-free at elevated temperatures, noncorrosive, virtually static-free and do not sweat or drop from condensation. Grilles are available in single and double deflection types with individually adjustable air-foil bars. Grille line is offered in popular sizes with vertical or horizontal bar mountings. **AirGuide Plastics Corp, 20 S E 3rd Ave, Miami 32, Fla.**

Circle 331 on Reader Service Card

Electronic batch counter . . .

has been redesigned to be suitable for all types of batch counting, machine cycling and packaging operations. Available with wide range of plug-in sensing devices. Also offers remote control operation, addition of fifth decade for greater counting capacity, automatic zero set. Basic three-decade unit is $295. **Standard Instrument Corp, 657 Broadway, New York 12.**

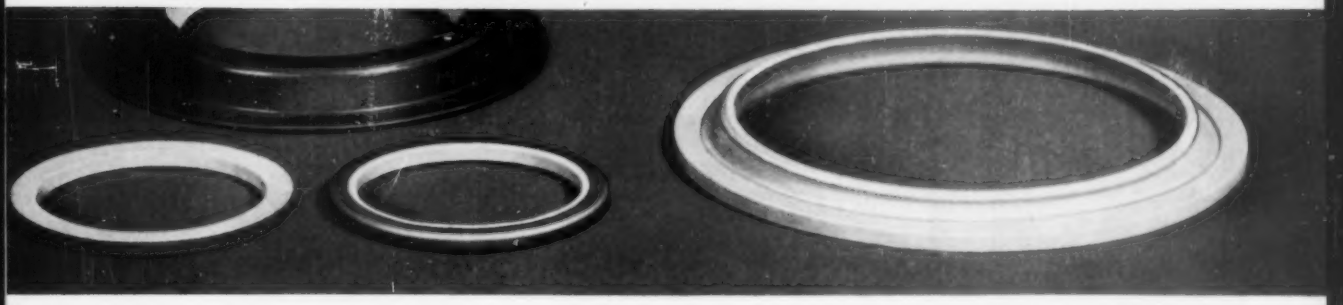
Circle 332 on Reader Service Card

Electrical thermometer . . .

determines surface and immersion temperatures in laboratory or production applications. Model T-1 has ½ in. dia probe, 7 in. long, connected to instrument body and direct-reading meter by thin, five-conductor cable about 30 in. long. Range is from —20 to 180 C, with accuracy of ±1 to 1½ C. **Ameresco Inc, 7 Center Ave, Little Falls, NJ.**

Circle 333 on Reader Service Card

WHAT TYPE "RUBBER" MAKES THE BEST PARTS?



If there was one answer to the question above,

Garlock's job of compounding, molding, and extruding rubber to your specifications would be extremely simplified. But, as you know, each type of rubber has its strong points:

For example, Natural Rubber

is resilient, has high tensile strength . . . perfect for air springs, tubing, electrical insulation. *Styrene butadiene* has excellent resistance to aging, costs less . . . applied widely as weather stripping, bushings and grommets, gaskets. Other popular types—nitrile, neoprene, butyl, silicone, new Viton*—will each perform better under one set of conditions than another.

Molded and Extruded Rubber

parts are more of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. Call your local Garlock representative, or write for Catalog AD-167.

Make the right choice.

Discuss your designs with Garlock; find out what rubbers will do the best job for you. Learn, too, about Garlock's complete processing facilities . . . about the thorough quality-control and testing programs. You will find Garlock an ideal source for all your molded, extruded, and die-cut rubber parts.

*DuPont Trademark

THE GARLOCK PACKING COMPANY, Palmyra, New York

For Prompt Service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

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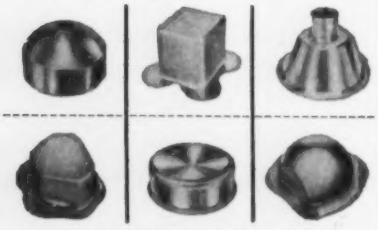
You can depend on KAUPP for complete service from design to delivery on precision-made metal parts and sub-assemblies. Ultra modern metal working facilities, plus wide experience on military and commercial requirements are available to solve your problems. Send drawings for quotations or phone for new illustrated bulletins!



Closest tolerances adhered to in all metals, including MU METAL, BRASS, INCONEL, ALUMINUM, COPPER, CARBON STEEL, STAINLESS STEEL, NICKEL, MAGNESIUM, TITANIUM, SILVER, SPECIAL ALLOYS, HAYNES STELLITE.

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 90.

THREADED AND HEADED FASTENERS—1960 Catalog, 150 pp. Dimensional and packaging information on threaded and headed fasteners. List prices reflect current changes. Atlas Screw & Specialty Co Inc, 450 Broome St, New York 13.

Circle 340 on Reader Service Card

GUIDE TO STEEL ANALYSES—Pocket-size booklet, 20 pp. Lists compositions of 40 stainless steels, 184 alloy steels and 105 carbon steels. Also contains federal specifications with corresponding SAE, AISI and AMS numbers. Stainless and Strip Div, Jones & Laughlin Corp, Box 4606, Detroit 34.

Circle 341 on Reader Service Card

VACUUM FORMING—Brochure, 16 pp. Explains technique and indicates design conditions under which it can be used. Includes photos of vacuum-formed products and diagrammatic cross-sections and colored inserts to clarify principle of basic process and drape-forming and plug-assist variations. Eastman Chemical Products Inc, Kingsport, Tenn.

Circle 342 on Reader Service Card

HYDRAULIC, ELECTRICAL AND MECHANICAL EQUIPMENT—Catalog 591, 60 pp. Engineering specifications, technical drawings and suggested applications are given with descriptions of each item of equipment. A special section is devoted to hydraulic equipment. Groban Supply Co, Dept P, 1139 S Wabash Ave, Chicago 5.

Circle 343 on Reader Service Card

SELF-SEALING FASTENERS—Catalog 359A, 16 pp. Illustrates and describes line of high-pressure, vibration-resistant seals and fasteners. Also covers armored bladed power connectors for electronic and electrical equipment. APM Corp, 252 Hawthorne Ave, Yonkers, NY.

Circle 344 on Reader Service Card

VIBRATION INDUCERS—Catalog, 38 pp. Dimensions, ratings and operational characteristics are given, with prices, for 52 sizes and types of vibration inducers. Martin Engineering Co, Neponset, Ill.

Circle 345 on Reader Service Card

BASIC CHEMICAL PRODUCTS—Catalog, 36 pp. Lists specifications, end uses and characteristics of more than 1000 products in general areas of basic chemicals, monomers, polymers, resins, adhesives, coatings, plastic products, fine chemicals, organic intermediates and biochemical reagents. Dept H, Borden Chemical Co, 350 Madison Ave, New York 17.

Circle 346 on Reader Service Card

PULSE TRANSFORMERS—Catalog, 24 pp. Contains definitions, a discussion of pulse transformer theory, application aids, testing and inspection tolerances, miniature and subminiature pulse transformers, pulse modulation and magnetron transformers and ordering information. Pulse Engineering Inc, 560 Robert Ave, Santa Clara, Calif.

Circle 347 on Reader Service Card

MAGNETIC CLUTCHES—Booklet, 18 pp. Information on design and applications, technical and testing specifications. Pic Design Corp, 477 Atlantic Ave, E Rockaway, NY.

Circle 348 on Reader Service Card

UNIVERSAL JOINTS AND DRIVES—Bulletin, 16 pp. Describes three series, each in its own section. Contains specifications and list of standard yoke part numbers with data on bore sizes, keyways, setscrew holes. Neapco Products Inc, Pottstown, Penna.

Circle 349 on Reader Service Card

ELECTRONIC HOLDING COMPONENTS—Catalog, about 48 pp. Reference manual of more than 2000 products, including features, specifications, applications and prices. Atlas E-E Corp, 47 Prospect St, Woburn, Mass.

Circle 350 on Reader Service Card

CORROSION PREVENTION—Catalog CRC-3-36, 8 pp. Explains how liquid corrosion preventative is applied, how it works, its duration of effectiveness and presents physical specifications. Corrosion Reaction Consultants Inc, 116 Chestnut St, Philadelphia 6.

Circle 351 on Reader Service Card

HYDRAULIC AND PNEUMATIC CONTROL VALVES—Brochure, 8 pp. Describes and illustrates various hydraulic and pneumatic control devices, with spe-

(Continued on page 82)

Protects your product . . . improves its looks . . . *and handles well in production*

Your product can have extra sales appeal easily and economically with either of these versatile, easy-to-clean finishes in this established top-quality vinyl. *Masland Duran Clad* can be laminated to metal. Even shearing, crimping, punching, drilling won't impair its texture or color. Wide decorative range. *Masland Duran Clad-On* with adhesive coated back for quick, easy application. Many outstanding colors and textures. Helps cut down your finishing costs.

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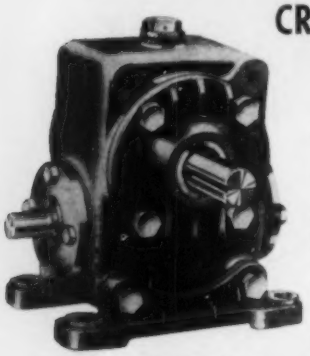
CROFTS UNIVERSAL MOUNTING WORM GEAR REDUCERS



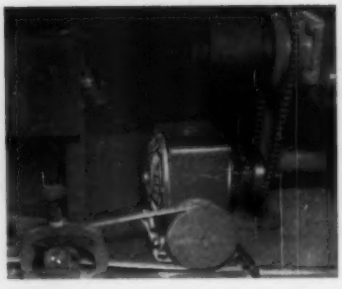
ALTERNATE FOOT MOUNTING POSITIONS

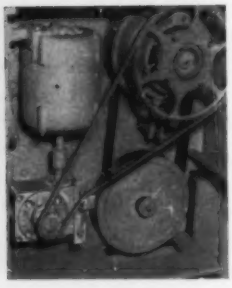
You just can't beat these small, rugged worm gear reducers. They can be mounted anywhere, in practically any position, and left alone to do their job.

Developed, tried and proved throughout North and South America, Crofts Universal Mounting Worm Gear Reducers and Gearmotors are available *from stock* in sizes 1-⅛", 1-¾", 2-¼" and 3" centers; up to 6 hp.; ratios up to 60:1.

For general information request Speed Reducer Bulletin C-571 (single reduction), C-5744 (double reduction) and Gearmotor Bulletin C-5914. We will be pleased to make recommendations on your speed reduction problems.

Typical installations showing the versatility and compactness of Crofts Universal Mounting Worm Gear Reducers.





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cifications and performance characteristics. Hydra-Power Corp, Pine Ct, New Rochelle, NY.

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STANDARD BLOWER HOUSINGS–Catalog, 16 pp. Dimensional specifications and prices for standard model housing and components. Housings are for blower wheels 3 through 11 in. dia and adaptable to any width, single or double inlet wheel. Detroit Stamping Co, 350 Midland Ave, Detroit 3.

Circle 353 on Reader Service Card

HYDRAULIC CYLINDERS – Catalog-engineering guide 117, 12 pp. Features and performance information on high-pressure hydraulic cylinders are illustrated and described. Hydraulic pressure and flow data, an explanation of how to calculate forces required for acceleration and deceleration, and figures and table to determine over-sized rod and stop tube applications are also presented. S-P Mfg Corp, 30201 Aurora Rd, Cleveland 39.

Circle 354 on Reader Service Card

PHYSICAL BASIS OF FAILURES–Booklet PIB 12, 8 pp. Discusses development of equations to determine physical basis of failures. Contains 22 diagrams and establishes a general mathematical basis for predicting point of failure. General Electric Co, 3198 Chestnut St, Philadelphia 4.

Circle 355 on Reader Service Card

METALS–Brochure, 3rd edition, 10 pp. Describes solid and clad metals, solid and clad precious metals, thermostat metals, electrical contacts and industrial metals. Texas Instruments Inc, Metals & Controls Div, 34 Forest St, Attleboro, Mass.

Circle 356 on Reader Service Card

STATIC INVERTERS–Brochure, 12 pp. Covers design considerations and individual specifications, operational information, dimensional and circuit diagrams. Varo Mfg Co Inc, 2201 Walnut St, Garland, Tex.

Circle 357 on Reader Service Card

PRECISION TEST GAGES–Bulletin M-28A, 6 pp. Includes accuracy and sensitivity specifications, dial graduation reproductions of available capacities, finish specifications, models available, mounting dimensions and drawings. Martin-Decker Corp, 3431 Cherry Ave, Long Beach 7, Calif.

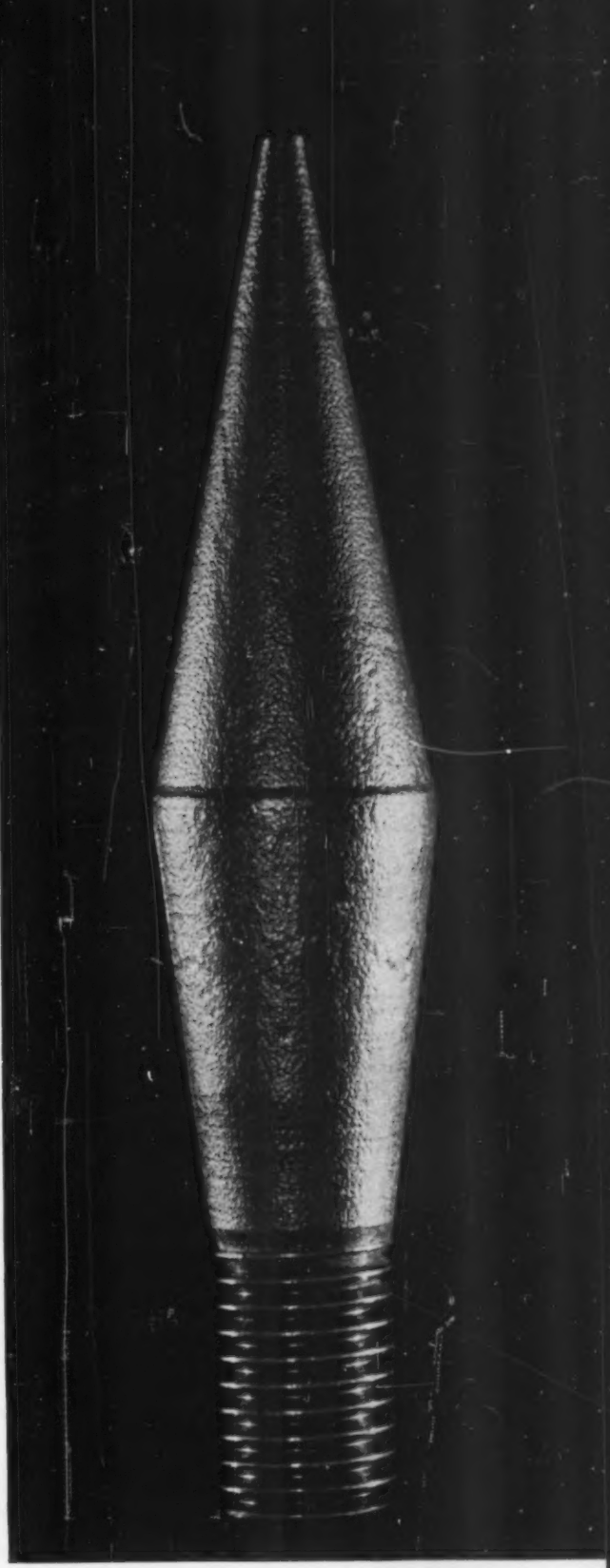
Circle 358 on Reader Service Card

POWER CONVECTION–Bulletin SC-182, 8 pp. Applications of power convection systems in heat treating technology are shown. Schematic flow diagrams of

(Continued on page 86)

Not a New Missile

it's a special fastener



It looks like it's ready to blast-off from Cape Canaveral. But see the threads? They give it away for what it really is—a fastener. And a very special kind, made by Bethlehem.

Our customer uses this special fastener as the point in a grip hook for steam log loaders. It's got to be strong and hard and tough. That's why we hot-forge it from a special alloy steel and heat-treat it. Other manufacturing operations: trimming, descaling, threading.

Forgings, bolts, nuts, rods, stampings—Bethlehem makes every kind of steel fastener specialty. Headed, threaded, pointed, bent, or slotted. Machined, punched, or drilled.

The nearest Bethlehem sales office will give you full details. Or write to us at Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

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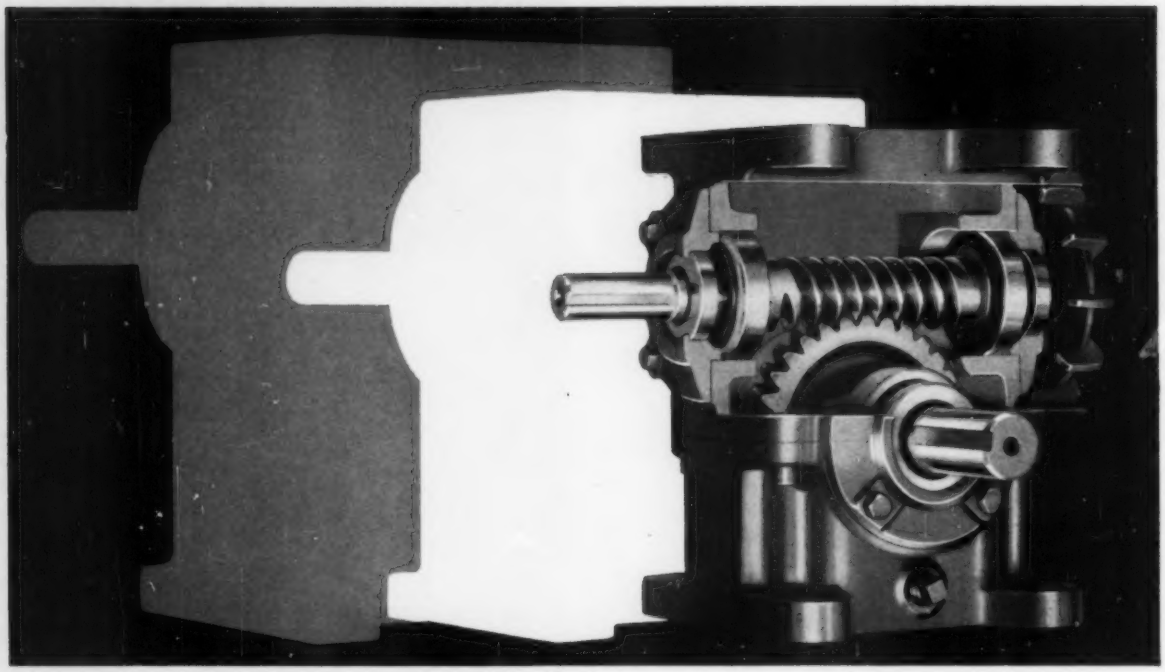
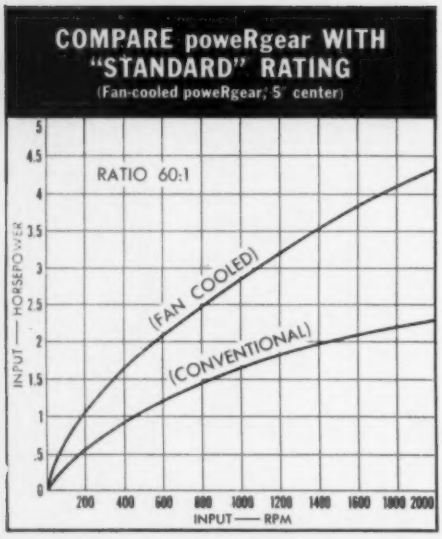
CIRCLE 83 ON READER SERVICE CARD

Based on performance, Morse Eberhardt-Denver Speed Reducers give you:

MORE CAPACITY FOR YOUR MONEY





These curves compare a 5 inch center distance poweRgear with a 5 inch center conventional non-fan cooled heavy duty unit. Because of its fan-cooled design and extra-heavy construction, a Morse E-D poweRgear Speed Reducer easily exceeds "standard" ratings . . . delivers more horsepower per dollar!

Fan and fin cooling, extra-heavy-duty construction let poweRgear® do *more* work in a given size; you save space and weight, often trim initial costs

You get *more* than "rule-of-thumb" ratings call for, when you specify stock Morse Eberhardt-Denver poweRgear Speed Reducers. You pick and pay for the capacity you *need* . . . get it, as set realistically by exhaustive laboratory tests and critical on-the-job ratings.

Fan-and-fin cooling holds operating temperature down, sends rated life up on a poweRgear reducer. Its universal design permits mounting in bottom, top or vertical positions and includes extra-heavy housing, shafts and bearings. Result: you can specify a smaller, lighter, more compact unit to do your job . . . get *more* capacity for every reducer dollar.

There's a Morse E-D poweRgear reducer for *every* job: fractional to 40 H.P.; ratios from 5:1 to 3600:1; center distances from 2" to 7". Other Morse E-D speed reducers: conveyor drives; miter boxes; helical reducers; gear motors; worm and gear sets.

FOR MORE FACTS, call your Morse distributor today (see the Yellow Pages under "Power Transmission.") Or write: Morse Chain Company, Dept. 4-129 Ithaca, N. Y. Export Sales: Borg-Warner Intl., Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

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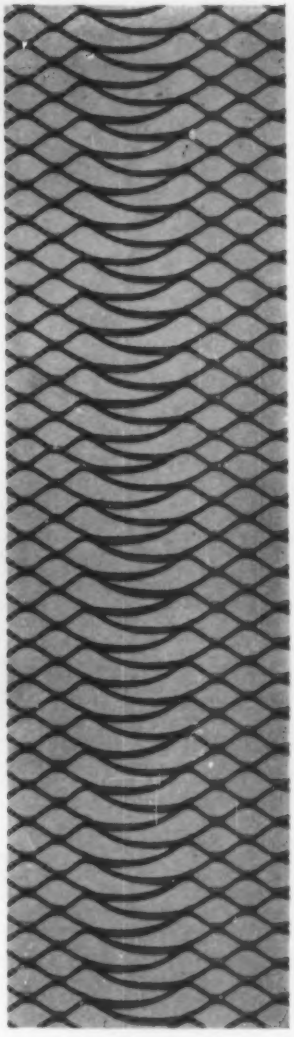
Oasis Dehumidifier by Ebco Manufacturing Co., incorporates a grille of Penmetal Garland expanded aluminum, shown actual size below.



Fresh expanded-aluminum pattern accents restyled dehumidifier

Clean lines . . . a crisp, new look that will last . . . greater utility . . . these are some of the qualities gained by Ebco designers in re-styling the Oasis dehumidifier.

The rich, anodized grille of Penmetal expanded aluminum handsomely accents the mocha-tweed vinyl-covered cabinet. Penmetal's new Garland pattern has depth and variety . . . is a lasting invitation to the eye. The golden color is an integral part of the metal . . . for permanent brilliance.

Expanded metal has high strength-to-weight ratio . . . comes in a number of exciting new patterns. For full details, send for illustrated folder 516-EM.

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General Sales Office: 40 Central Street, Boston 9, Mass.

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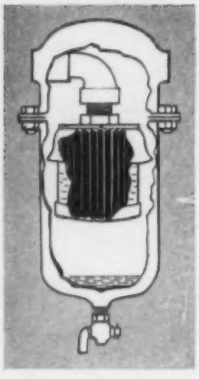
PM-216

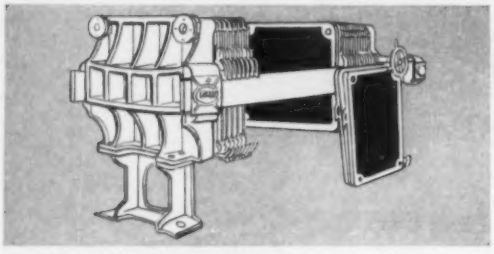
CIRCLE 85 ON READER SERVICE CARD

Why FELT BY FELTERS Makes An Ideal FILTERING MEDIUM



Felt has controlled permeability and particle retention efficiency which makes it ideal for filtration of air, gases and liquids. Wool felt is non-reactive to many chemical agents and can be made chemically neutral.

Felt can be fabricated into a wide variety of shapes for use in industrial air filtration, air conditioning, and for processing chemicals, paints, film dope and nutrient broths. Also ideal for use in particle retention for radioactivity monitoring.



CHECK THE FEATURES OF FELTERS' FILTRON-FELTS

• High flow rates • Withstands long immersion • Greater product recovery • Functions as gasket • Can be reused • Resists abrasion • Density can be controlled • Excellent filter cake build-up • Easy to shape, no raveling • Low cost

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Pioneer Producers of Felt and Synthetic Non-Woven Fabrics FED-17

Catalogs and Bulletins.....continued

typical systems are reproduced. Surface Combustion Div, Surface Combustion Corp, Toledo 1, Ohio.

Circle 359 on Reader Service Card

CONTINUOUS HINGES—Brochure, 12 pp. Specifications and dimensional information on continuous hinges. Rex Hinge Co, 1540 Coit Ave, East Cleveland 12, Ohio.

Circle 360 on Reader Service Card

CARD RECEPTACLES AND SOCKETS—Catalog, 8 pp. Specifications, schematics and dimensional information on card receptacles and sockets designed for switch gear, computers, instruments and other automatic control devices using printed circuitry. Methode Mfg Corp, 7447 W Wilson Ave, Chicago 31.

Circle 361 on Reader Service Card

THERMOCOUPLE WELLS—Catalog G102-1, 16 pp. Presents well designs and dimensions, rating, corrosion and thermocouple assembly information and ordering and pricing data. Minneapolis-Honeywell Regulator Co, Wayne and Windrim Aves, Philadelphia 44.

Circle 362 on Reader Service Card

SLIP RING ASSEMBLIES—Data file, 12 pp. Includes fundamental description of general-purpose units and power slip rings. Also contains illustrated data on various types of slip ring assemblies. Engelhard Industries Inc, 113 Astor St, Newark 2, NJ.

Circle 363 on Reader Service Card

TOOL STEEL FOR PLASTIC MOLDS—Pamphlet, 8 pp. Describes low-carbon tool steel for use in producing molds for plastics and die-casting dies for zinc and other metals with low melting points. Uddeholm Co of America, 155 E 44th St, New York 17.

Circle 364 on Reader Service Card

SELECTING RECORDING INSTRUMENTS—Bulletin GEA-6933, 12 pp. Provides dimensions and chart speeds, operating specifications, applications, features and accessories for use in buying proper recording instruments. General Electric Co, Schenectady 5.

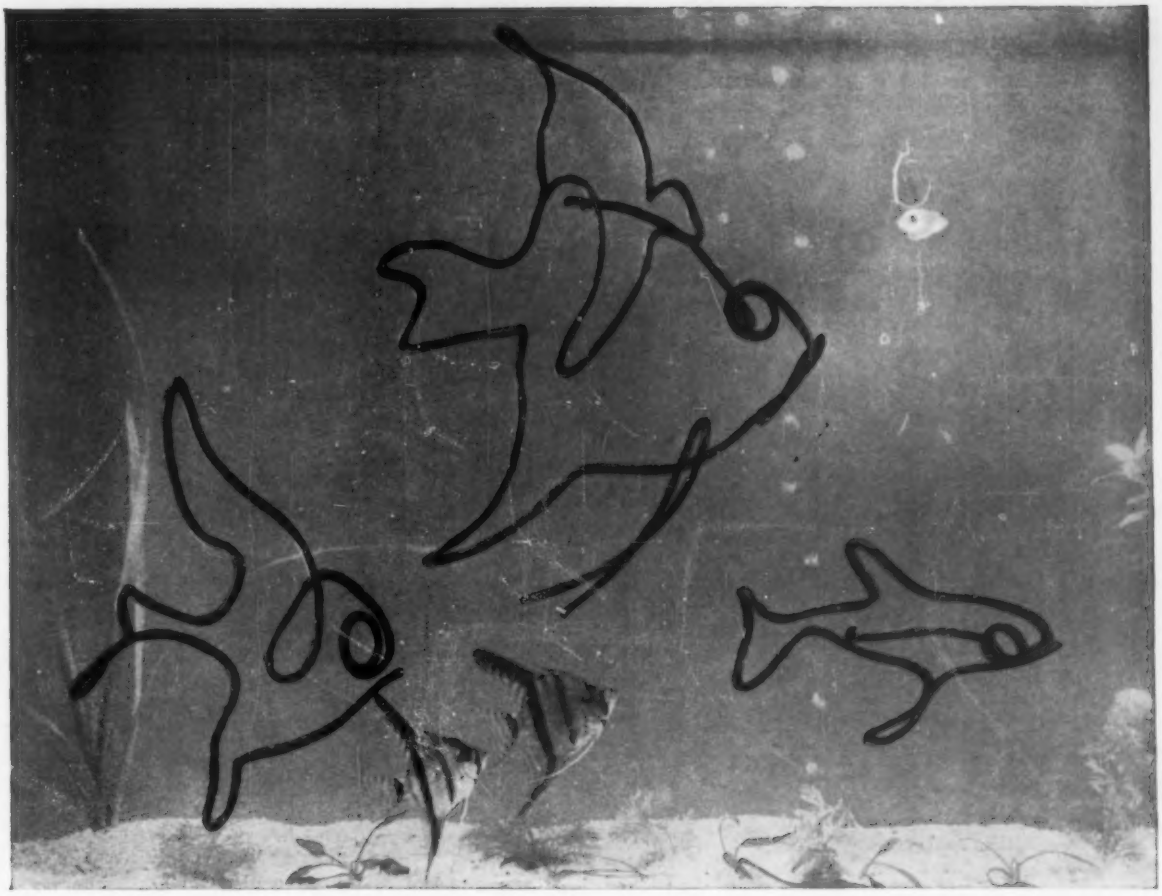
Circle 365 on Reader Service Card

HYDRAULIC VARIABLE - SPEED GEARS, 8 pp. Specifications, rating tables and performance information on various types of variable-speed gears. Crofts USA Inc, 2542 W Peterson Ave, Chicago 45.

Circle 366 on Reader Service Card

FURNACE BRAZING TECHNIQUES—Bulletin 592, 16 pp. Describes design,

(Continued on page 88)



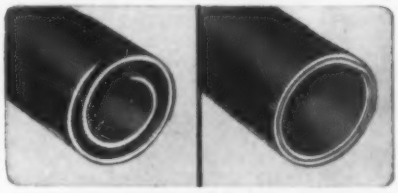
Bundy can mass-fabricate practically anything

. . . and we use Bundyweld®—the double-walled steel tubing—for parts that must meet rigid specifications

YOUR tubing headaches are Bundy's business. Our tubing engineers will work with you at any stage in the development of your product. With years of problem solving experience, we can often suggest short cuts that cut costs of tubing parts—or find practical solutions to tough bends.

Then we'll mass-fabricate these parts on machines specially designed by Bundy for precision bending. We use Bundyweld, the original double-walled steel tubing, that has become the safety standard in small-diameter tubing. It's thinner walled—yet stronger, has high bursting and fatigue strengths. Covered by Government Spec. MIL-T-3520, Type III.

Why don't *you* take advantage of Bundy's complete service: expert engineering help, mass-fabrication savings, ***Bundyweld*** tubing. For more information see Sweet's Product Design File, le/Bu . . . or contact us!



Bundyweld is the only tubing double-walled from a single copper-plated *steel* strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.

Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to $\frac{3}{8}$" O.D.

There's no substitute for the original Bundyweld Tubing.

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WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, AND ITALY

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materials, brazing medium, supporting fixtures, protective atmospheres and temperatures. Includes diagrams of typical assemblies. Electric Furnace Co, Salem, Ohio.

Circle 367 on Reader Service Card

ELECTRONIC EQUIPMENT—Catalog 59A, 12 pp. Contains descriptions and illustrations of electronic equipment for research and industrial uses. Included are dc power supplies, digital readout voltmeters, ac line voltage regulators, and information on custom design and prototype development engineering services available. Davenport Mfg Co, Dept PE-1, 2530-32 N Elston Ave, Chicago 47.

Circle 368 on Reader Service Card

SELF-LOCKING TAPPED HOLES AND INSERTS—Catalog, 4 pp. Specifications, dimensions and dimensional drawings. Banc-Lok Div, Boots Aircraft Nut Corp, Newtown Turnpike, Norwalk, Conn.

Circle 369 on Reader Service Card

ROTARY SOLENOID PRODUCTS AND SYSTEMS—Brochure, 4 pp. Illustrates and describes standard and special solenoids, packaged switch assemblies and 360° drive stepping units. Includes specifications and applications. Pacsol Div, Illinois Tool Works, 3155 El Segundo Blvd, Hawthorne, Calif.

Circle 370 on Reader Service Card

CENTER SCREWLOCK POWER CONNECTORS—Series 1900 brochure, 6 pp. Gives specifications, outline dimensions and general information on miniature power connectors with center screwlock. DeJur-Amsco Corp, 45-01 Northern Blvd, Long Island City 1, NY.

Circle 371 on Reader Service Card

METERING AND MIXING EQUIPMENT—Brochures 101 and 102, 4 and 6 pp. Form 101 explains automatic metermixer for two-part compounds and adhesives. Form 102 features air-powered automatic metering, mixing and dispensing equipment for continuous operation with viscous compounds in large volume. Pyles Industries Inc, 20855 Telegraph Rd, Detroit 41.

Circle 372 on Reader Service Card

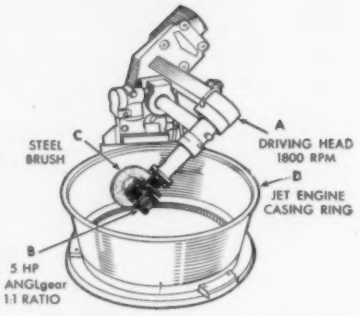
ONE-PIECE NYLON FLIP GROMMET—Bulletin, 4 pp. Illustrated and describes features, installation and specifications of one-piece solid nylon grommet. Western Sky Industries, 21301 Cloud Way, Hayward, Calif.

Circle 373 on Reader Service Card

VOLTMETER—Catalog sheet, 2 pp. Covers features and applications. In-

(Continued on page 90)

ANGLgear® simplifies power-brush drive

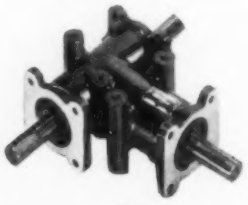


Drawing shows ANGLgear application on Osborn Brushamatic® unit developed for finishing jet engine case components. ANGLgear permits compact design, has capacity to withstand reversal every 20 sec. without overheating.

Osborn Manufacturing Co., a Cleveland, Ohio, producer of power-brush finishing machinery, has found ANGLgear ideal for adapting brushing heads to right-angle drive. Offering high capacity for its size, ANGLgear permits compact head design, facilitates brushing in restricted spaces. At the same time, its light weight cuts the overhung load to a minimum, helping reduce bearing wear. And it has the stamina to meet operating conditions that include reversal every 20 seconds—without overheating or undue wear.

Perhaps ANGLgear can solve a similar 90° drive problem for you. Completely enclosed, permanently lubricated, and featuring universal mounting, it is easily incorporated in your power transmission systems and requires little or no maintenance.

You can specify standard ANGLgear in ⅓, 1, 2¼ and 5 hp ratings, with 1:1 or 2:1 gearing and 2 or 3-way shafting. See data in Sweet's Product Design File or contact our local distributor.



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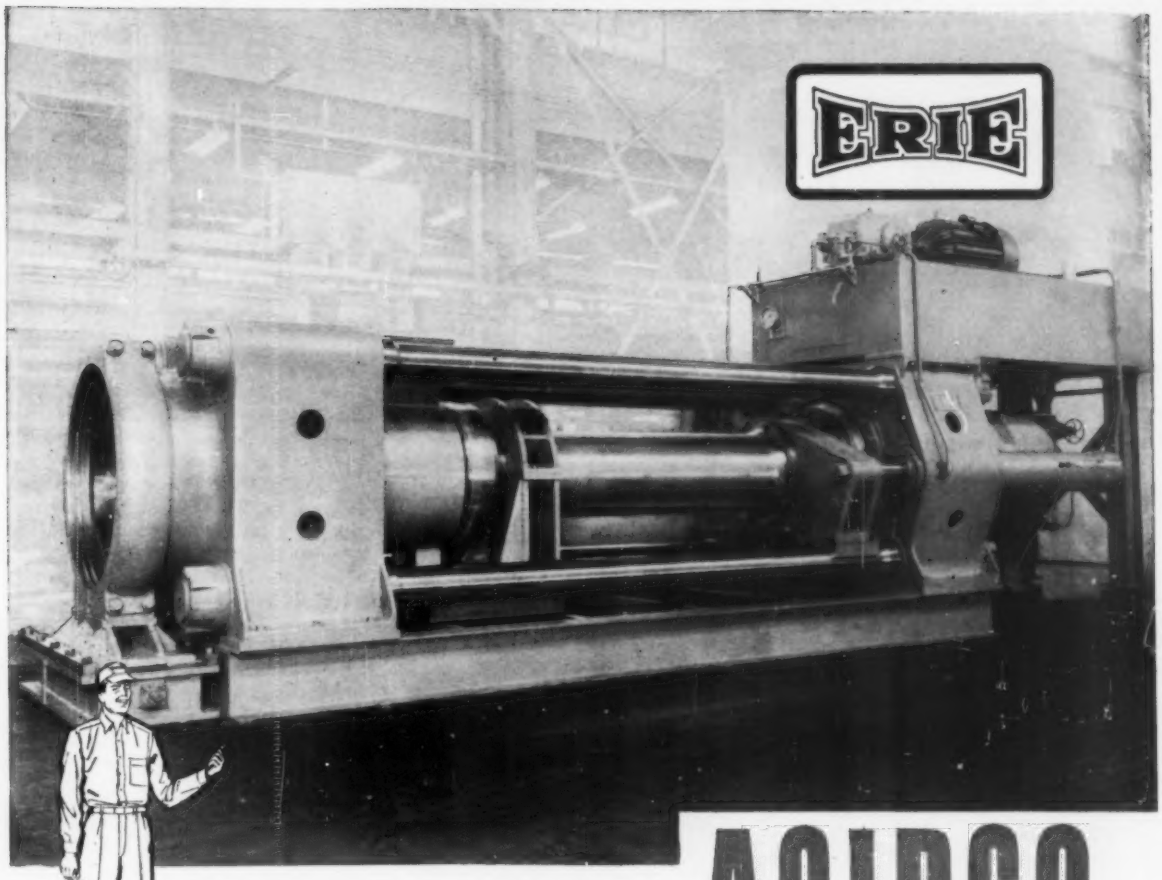

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ERIE FOUNDRY CO. PICKS ACIPCO TUBING FOR CARBON EXTRUSION PRESS PLUNGER

You're looking at a new 2000-ton horizontal carbon extrusion press manufactured by the Erie Foundry Company's hydraulic press division. Designed for the production of carbon electrodes, the press features ACIPCO centrifugally spun steel tubing in its main ram plunger.

Custom-spun by ACIPCO, the plunger is 30.50″ O.D. with 125 micro-inch finish and 2-5/8″ wall thickness. Main ram is 42″ in diameter and has a 105″ stroke. Produced with heads statically cast at ACIPCO, the plunger's overall length is 144″.

Fabricated applications such as this are a specialty with ACIPCO. Completely equipped to solve a wide variety of tubing problems, ACIPCO can serve your needs more efficiently and economically because all its facilities are under one roof. For expert consultation on centrifugally spun tube applications in your field . . . call on ACIPCO.

VERSATILE ACIPCO CENTRIFUGALLY SPUN STEEL TUBES

SIZE RANGE: Lengths up to 410″ to meet modern machinery requirements have been produced. OD's from 2.25″ to 50″; wall thicknesses from .25 to 4″.

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special non-standard analyses.

FURNISHED: As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.

SPECIAL PRODUCTS DIVISION

AMERICAN CAST IRON PIPE CO.

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CIRCLE 89 ON READER SERVICE CARD

ALLEN

The cost of ALLEN Hex-Socket Cap Screws is only a minor fraction of your assembly costs . . . be sure you're getting the timesaving, cost-saving advantages of genuine Allens!

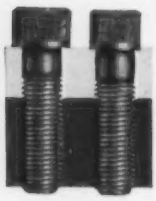
Ever since Allen first produced the hex socket head screw nearly fifty years ago, specifying *genuine* Allens (made by Allen of Hartford) has been a sure way to guarantee dependable threaded fastening.

Only *genuine* Allens have Leader Points that make starting easier, and greatly minimize danger of cross threading. *Genuine* Allens are "pressur-formd" to preserve the long fibers uncut throughout the length of the screw, giving stronger sockets for greater tightening torque.

Write for samples and engineering data. See how *genuine* Allens will make your product better.

ALLEN HEX-SOCKET SCREWS HEAD

Allen's new 1960 Series Socket Head Cap Screws give up to 2½ times more load carrying capacity, without indentation.



Head diameter of sizes from ¼" up is now uniformly 1½ times the body diameter—providing more under-the-head bearing surface, and a proportionate increase in clamping force. Write for new Bulletin G-25, with full specifications.

Stocked and sold by leading Industrial Distributors everywhere

ALLEN MANUFACTURING COMPANY
Hartford 1, Connecticut

90 CIRCLE 90 ON READER SERVICE CARD

cludes specifications and schematic diagram. Southwestern Industrial Electronics Co, Div Dresser Industries Inc, 10201 Westheimer, PO Box 22187, Houston 27.

Circle 374 on Reader Service Card

PRESSURE CUTOFF—Bulletin 103, 2 pp. Description, illustration and operational information on PE-103 pressure cutoff. Also includes specifications and wiring diagram. Datex Corp, 1307 S Myrtle Ave, Monrovia, Calif.

Circle 375 on Reader Service Card

MATERIAL FINISHING EQUIPMENT—Bulletin, 4 pp. Describes new methods of material finishing, including one that will give automatic finishing and will load parts and media and another that will handle parts made of ferrous or nonferrous metals and plastic or rubber materials. Conveyor Corp, Finishing Div, 30121 Groesbeck Highway, Roseville, Mich.

Circle 376 on Reader Service Card

CLUTCHES, POWER TAKE-OFFS AND GEAR REDUCTION UNITS—Bulletin, 4 pp. Presents various equipment, together with dimensions, torque capacity and suggested applications. Also includes outline drawings. Rockford Clutch Div, Borg-Warner Corp, 400 Catherine St, Rockford, Ill.

Circle 377 on Reader Service Card

TENSILE TESTING MACHINES—Bulletin T-859, 4 pp. Describes manual and motorized hydraulic testing machines with capacities to 40,000 lb. Steel City Testing Machines Inc, 8817 Lyndon Ave, Detroit 38.

Circle 378 on Reader Service Card

Letterhead Requests Only

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

BAR STOCK, BUSHINGS AND SHAPES—Bullettin 45, 16 pp. Illustrates typical parts machine, from standard shapes. Shows how bars, bushings and shapes, cast in standard sizes to exacting physical properties are used for cams, pistons, gears, plates, box and flat parallels. Meehanite Metal Corp, 714 North Ave, New Rochelle, NY.

BI-METALLIC CASTING—Brochure, 8 pp. Discusses molecular bonding process that bonds ferrous components into aluminum castings. Patented casting process, called Al-Fin molecular bonding, bonds aluminum alloys to cast iron, alloy and stainless steels, nickel, titanium and other metals. Arthur Tickle Engineering Works, 21 Delevan St, Brooklyn 31, NY.

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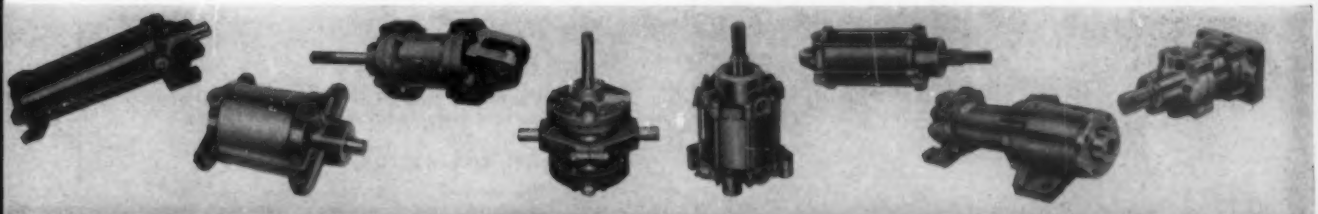
POWER CYLINDERS SAVE YOU TIME, TROUBLE AND MONEY

Select your needs

from the World's Widest Selection of Standard Cylinders



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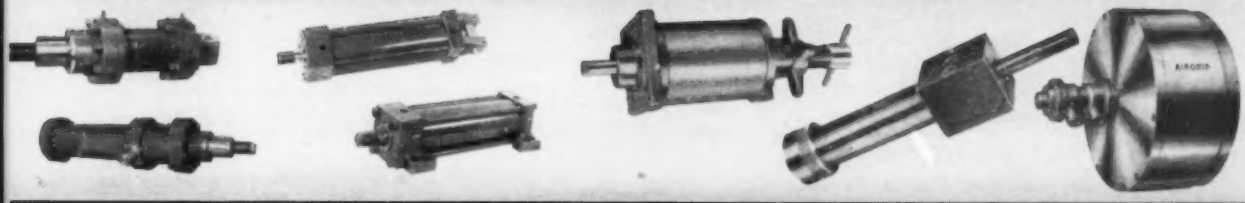

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Precision ferrous and non-ferrous powder metal parts are available from Mueller Brass Co. through its subsidiary, The American Sinteel Corporation.

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How they behave under plasma jet oxy-acetylene torch and rocket-engine exhaust. Nov 23 **Circle P 22**

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Mathematical tools as applicable to bearings, gears and rivets as they are to vacuum tubes or capacitors. Nov 16 **Circle P 21**

Reinforced-plastic Springs
Leaf springs from epoxy laminates can outperform steel. Nov 9 **Circle P 20**

Latest Trend in Bolt Threads
Root radius is getting larger—75% threads now; 55% threads a possibility. Nov 9 **Circle P 19**

18 Ways to Control Gear Backlash
This roundup includes latest devices for answering a chronic problem. Oct 26 **Circle P 18**

Pressure Drops in Pneumatic Systems
New method predicts losses when components are in series. Oct 26 **Circle P 17**

Yardsticks for Research Success
Equations and procedures used to gage the future of a product. Oct 19 **Circle P 16**

8 Steps to Better Engineering Writing
This eight-part report appeared in serial form from Sep 7 to Oct 26 **Circle P 15**

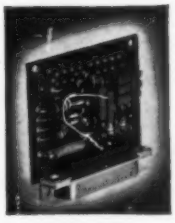
3 Steps to a Battery-powered Motor
Electric auto is example—how to choose

(Continued on page 94)

A topper in any language

It's better than the best XXXP grade, it's lighter and more economical than G-10, it's Taylor XY-1 Paper-Base Epoxy Laminate

When you want extremely high reliability in printed circuits, with the additional advantages of flame retardance, chemical resistance, good solderability and high bond strength—specify Taylor XY-1 copper-clad laminate. It is self-extinguishing in 1 second, has excellent resistance to alkalis, acids and solvents, has a solder time resistance at 500°F. of 30 seconds in 1-oz. copper and 50 seconds in 2-oz., and a bond strength of 10 lb. in 1-oz. copper and 13 lb. in 2-oz. Sheets available with copper on one or both sides.



Unclad Taylor XY-1 has many advantages, too. It can be substituted for glass-base epoxy laminates to reduce cost and weight. It has excellent electrical, mechanical and machining properties. Contact us for complete technical data and expert guidance in applying this new material. TAYLOR FIBRE CO., Norristown 39, Pa.

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For predicting service performance, look at the miscrostructures. Oct 12
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Planetary Drive Run by Rollers
Replacing gear drive cuts noise and vibration in fast planetary system. Oct 12
Circle P 12

Molding with Polyester Premixes
A different design approach is necessary with these reinforced plastics. Oct 12
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Combined reprint: test methods for torque, vibration and runout. Sep 14; devices to check preload and play. Sep 28
Circle P 10

Specifying Anodized Aluminum Finishes
Practical guide to ways that will give the specific coating needed. Sep 28
Circle P 9

13 Ways to Cut Drafting Costs
List of helpful modern methods, materials and equipment that save money. Sep 28
Circle P 8

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Three-step method chooses type and rating for power and control. Sep 28
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Cast Epoxies Give Time-saving Models (12/21/59)
A discussion on how these plastics will

(Continued on page 96)

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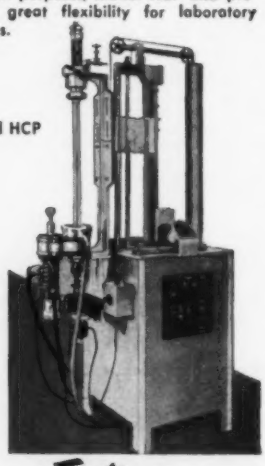
A new floating zone fixture for the production of ultra-high purity metals and semi-conductor materials. Purification or crystal growing is achieved by traversing a narrow molten zone along the length of the process bar while it is being supported vertically in vacumm or inert gas. Designed primarily for production purposes, Model HCP also provides great flexibility for laboratory studies.

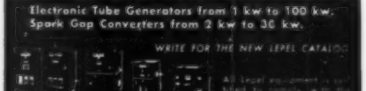
Model HCP



Features

- **A smooth, positive mechanical drive system with continuously variable up, down and rotational speeds, all independently controlled.**
- **An arrangement to rapidly center the process bar within a straight walled quartz tube supported between gas-tight, water-cooled end plates. Placement of the quartz tube is rather simple and adapters can be used to accomodate larger diameter tubes for larger process bars.**
- **Continuous water cooling for the outside of the quartz tube during operation.**
- **Assembly and dis-assembly of this system including removal of the completed process bar is simple and rapid.**

Electronic Tube Generators from 1 kw to 100 kw.
Spark Gap Converters from 2 kw to 30 kw.



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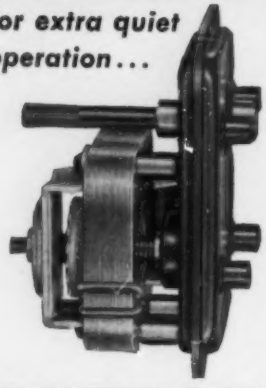

MOTORS

with gear reductions

Designed for low-speed, high-torque applications, GI Gear Motors are widely used in TV Remote Control Units, Vending Machines, Timing Devices, etc. Molded nylon gears in a dirt-sealed housing insure extremely quiet running plus rugged dependability. Rotor disengages, if required, when gear train is de-energized. For reliability, plus extra silent service, specify GI Gear Motors. Precision-made, with mass-production economy.

GENERAL SPECIFICATIONS

MODEL 205		
	Intermittent	Continuous
SPEED	13 RPM	13 RPM
TORQUE	150 in./oz.	100 in./oz.
AMPS, No Load	2.5	1.25
WATTS, No Load	26	13
REVERSIBLE	No	No
CONDENSER	None	None
MODEL 308		
	Intermittent	Continuous
SPEED	13 RPM	13 RPM
TORQUE	150 in./oz.	90 in./oz.
AMPS, No Load	1.2	0.6
WATTS, No Load	24	12
REVERSIBLE	Yes	Yes
CONDENSER	60 MFD	60 MFD

Above data based on 24 volts—Intermittent Duty 3 minutes on and 5 off. Both models can also be supplied for 115 volts — 60 cycles.

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give shortcut prototypes. R25

Selecting the Right Electrical Connection (12/7/59)
This special report compares all types—permanent and separate. R24

Structural Models (10/26/59)
In three parts: I—Theory of Similitude; II—Building the Better Model; III—The Model at Work. R23

Engineering Organization in Transition (5/11/59)
Study of some 50 organizations showing their latest setups, reasons for changes, budgeting, titles and ratios of engineers to total company employment. R22

The Engineer's Bookshelf (New—3/30/59)
Detailed bibliography of technical books for the design engineer. Handbooks, texts (22 subject classifications), bibliographies, library references and periodicals. R21

Designing with Swivel Joints
How to choose between swivels and flexible hose; how to select the proper type or combination of joints, and calculate pressure loss. R20

Modernize Now
Why and how to modernize the engineering design function: how to calculate R & D investment, costs and manpower needs; engineering laboratory, drafting equipment; company library; model shop. R19

Sandwich Panel Materials
Selection guide for core materials, facings and adhesives—presented in tabular form. Core materials include vegetable, mineral and plastic in solid, honeycomb and foam. Data on facings, cover metal, wood and plastic. Adhesives table lists properties for the 14 most widely used. R18

The Engineer Comes Into His Own (3/31/58)
Summary of current thinking on what makes him tick; his growing ties with other sciences; his responsibilities as individual, citizen and human being . . . and what tomorrow holds for him. R17

Pre-painted Steel (12/9/57)
Metal preparation, how to chose a paint, paints available. R14

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How to design hydrodynamic gas bearings including latest research information on gas bearings developed through a cooperative program sponsored by 11 government agencies. R13

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How texture and color are added to aluminum surfaces; texture and surface design, metallurgical finishes, application of color. R12

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. . . for effective sealing on Rods and Rams

This *advanced* form of V-type packing is offered in two distinctive designs for broad hydraulic and pneumatic service. Sets of *shallow* Palmetto Pyramid serve where the packing space is limited . . . *deep* Palmetto Pyramid sets are used where space is not a factor. Both designs have strong, heavy walls to resist extrusion — extend packing life.

In addition to Palmetto's unique adaptation of the "V" concept there is more to Palmetto Pyramid Packings than meets the eye. Reinforced styles, for example, are constructed with continuous plies of fabric — endlessly folded — that follow the molded form to withstand stresses exerted from all directions. Quality materials throughout, also not readily discernible, contribute to the performance you seek.

Palmetto's recommendations concerning the use of Pyramid Packings can be made quickly and accurately when the following is supplied:

• Your drawing showing dimensions and tolerences of the stuffing box and rod and of the piston and cylinder • A description of the fluid • Maximum pressure • Minimum and maximum temperature • Speed and direction of motion

SEND FOR LITERATURE—

Let us help you design-in a more effective seal. For complete technical data on Palmetto Pyramid Packings request your complimentary copy of Bulletin PY-959.

NOTE: Another useful packing fact book, just printed, is available to design engineers. Ask for Bulletin GTR-759 covering Palmetto G-T Rings.

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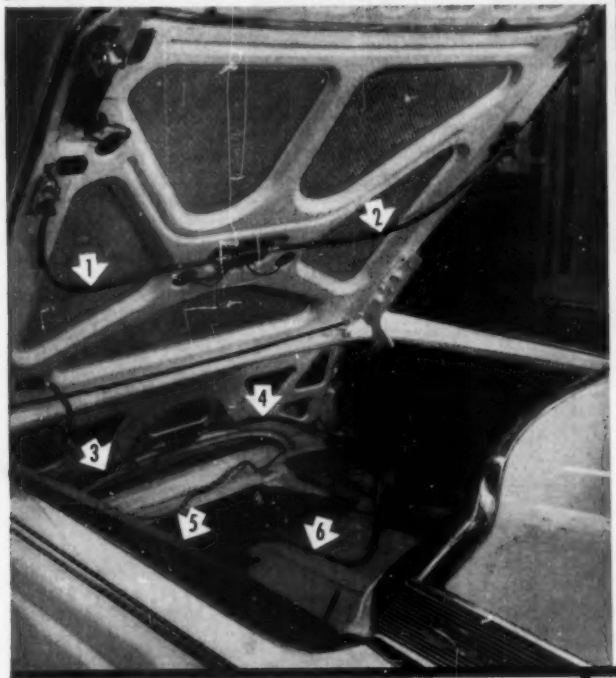
S. S. White DRIVE AND CONTROL IDEAS FOR ENGINEERS

Tips on better designing with flexible shafts

REMOTE CONTROL AND POWER DRIVE:

Retractable hard top simplified by flexible shafts.



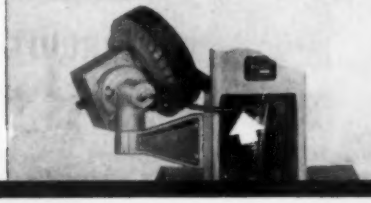
In the Ford Fairlane 500 Skyliner, the roof retracts into the trunk, and the trunk lid closes and locks. All this is done automatically, within 40 seconds. Powering this ingenious mechanism are six 3/16" high speed, remote control flexible shafts, driven by three reversible electric motors.

The use of flexible shafts enabled the designers to use only one motor to drive each pair of actuators, thus solving synchronization problems and at the same time cutting down on the number of motors needed.

Flexible shafts (1) and (2) rotate the trunk lid locking screws in and out of engagement. Flexible shafts (3) and (4) drive a pair of screw-jack actuators to raise or lower the trunk lid. Flexible shafts (5—not shown) and (6) drive a pair of actuators and their associated linkage to raise or retract the roof.

POWER DRIVE:

Powering a movable component . . . is easily accomplished with flexible shafts. Position of barrel type feeder on this new Detroit Power Screwdriver is highly adjustable, because it is driven by a flexible shaft. Power take-off is at the main drive motor.



COUPLING:

Solve alignment and vibration problems . . . with S. S. White coupling shafts — short pieces of flexible shafting without companion casings. Here is one being used between an adjustable pulley and a gear pump.

1057

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FIRST NAME IN FLEXIBLE SHAFTS

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10 East 40th Street, New York 16, N.Y.

Selection of S. S. White standard flexible shafts: complete description and application data available. **Write for bulletin 5801.**

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Selection of specialized flexible shafts to meet unusual requirements: useful shaft data and also information on how to take advantage of S. S. White engineering services. **Write for bulletin 5601.**

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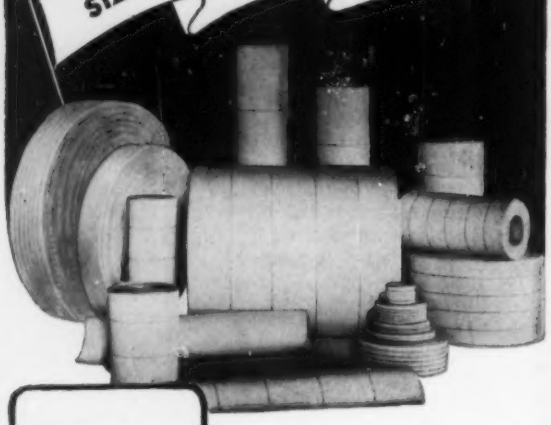
200 SIZES · 35 WIDTHS · 7 THICKNESSES



SIX SPECIAL SURFACE TREATMENTS are available to make Buffalo Belts resistant to heat, cold, grease, oil, acid, alkalis and water.

These SOLID WOVEN COTTON BELTS WILL LAST LONGER and COST YOU LESS!

No matter what your requirements are in conveyor belting, you can generally fill the bill with a Buffalo Conveyor Belt. 65 years experience has made this one of the most extensive lines in existence. Our exclusive WOV-IN-WEAR Process actually weaves years of extra wear into these belts which makes them pliable and "bouncy". BUFFALO BELTS ABSORB IMPACT and ABRASION much like a pillow absorbs a blow. Consequently, they LAST LONGER . . . COST LESS!

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that fully illustrates and describes our belts, their sizes, prices and uses.

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We also manufacture a complete line of WOVEN COTTON CONVEYOR BELTS and PURE SHEET RUBBER

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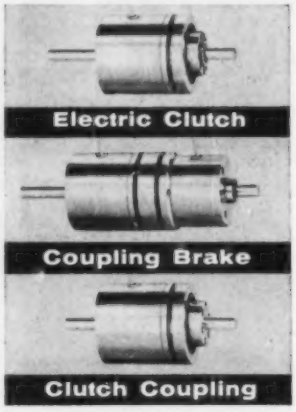
FIXED FIELD ELECTRIC CLUTCHES



Three styles from 7/8" to 3 1/8". Torque output from 10 oz. inches to 100 lb. inches.

In Miniature & Small Sizes

Introduced only a few short months ago, Simplatrol Fixed Field Electric Clutches have found popular application wherever space is tight, noise is objectionable and performance requirements are rigid.

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No other electric clutch and brake can duplicate the patented Simplatrol diaphragm . . . the *only* moving part in Simplatrol Fixed Field Clutches. Here is a proved advantage . . . offering an absolute minimum of maintenance.

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DESIGN ABSTRACTS

Fasteners–Six Ways to Save Money

Six areas where standardization on certain types and sizes of fasteners should reduce purchase costs and inventories are discussed: thread series, class of fit, bolts vs. studs, head style, material specifications, plating specifications.

"Six Easy Ways to Save Money in Fasteners", F. E. Graves, Russell, Burdsall & Ward Bolt & Nut Co. American Standards Assn, Inc, 70 E 45th St, New York 17.

Image Quality and Information

Experiments conducted to determine relation between quality of transmitted image and the amount and quality of information obtainable from it are described. A technique for evaluating the usefulness of various quality imagery is under development. Much work remains to be done, particularly in the areas of subjective analysis as opposed to form recognition.

"Image Simulation and Interpretation", G. L. Meyer, Astro-Electronic Products Div, Radio Corp of America, Princeton, NJ.

Deflection of Asymmetric Beams

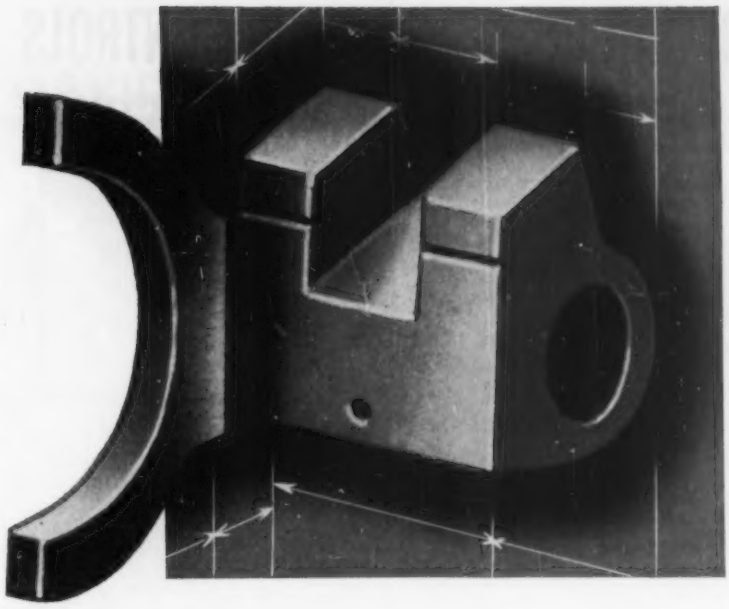
First the effects of force on symmetric beams are discussed. Then, for the purposes of this paper, a symmetric beam under the action of an oblique force is regarded as asymmetric. A method of determining axes, particularly the principal axes which give deflection in line with applied force is then described.

"The Deflection of Asymmetric Beams", W. H. Sheppard. Mechanical World and Engineering Review, 31 King St W 3, Manchester, England.

Ultrasonic Measurement of Corrosion

A method of making nondestructive thickness measurements from one side on steel, using an ultrasonic gage, is described. Accuracy of the "slide rule" method of calibration is detailed, the various sources of error

(Continued on page 100)



this new part brings outstanding cost reductions...

The photograph is of a shifter fork used in the transmission of a very popular garden tractor in volume production.

Clearly evident is the economy that can be achieved by powder metallurgy over other previously used methods. The elimination of practically all machine work effects striking cost reduction.

Made of pure powdered iron, infiltrated with copper to give added strength and ductility, this part is intended to meet the higher physical properties of wrought metals.

The user of this part naturally presented his problem to Bunting first.

For the unusual, as well as the usual, in bearings, bushings, bars and special parts of cast bronze, sintered metals, or Alcoa aluminum, see Bunting first.

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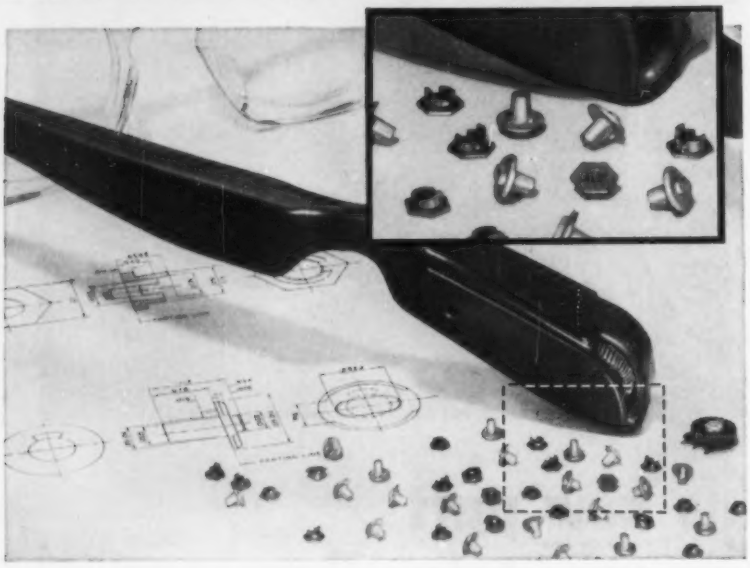
MINIATURE HEARING AID CONTROLS DEPEND ON TINY GRC DIE CASTINGS



Tiny, uniform zinc alloy parts to watchmaker's specs achieved through GRC's exclusive methods

A modern hearing aid small enough to fit into the temple piece of an eyeglass frame requires components and parts that must meet the same exacting specifications as the parts for a fine watch. Design engineers at Centralab, a division of Globe-Union, Inc., turned to Gries to produce the two tiny precision parts forming the mechanical center of a newly designed "Micro-Miniature" hearing aid volume control potentiometer . . . a .112" shaft and a bushing measuring .125" in diameter.

To function properly the two mating parts had to be manufactured within tolerances of ±0.0005". The shafts—9500 to a pound—were cast with a button-like disk and fastening lug at one end; a projecting tapered shaft for the bushing to rotate on and a stop lug to limit rotation on the other end. The even smaller—21,000 to a pound—slotted bushings were formed with a hex nut section and an extension to engage the shaft's stop lug. Electrical contact is made through the bushing.

This is a typical example of how GRIES' exclusive patented single cavity methods for automatically producing tiny, uniformly accurate, precision parts, economically solved a design problem. Whether simple or complex, quality is always high—no secondary operations, no scrap loss. GRC parts leave the machine ready for immediate use.

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examined, and means of compensating for them explained. Merits of the cathode-ray-tube resonance instrument are explained, and its efficiencies over earlier instruments outlined.

New techniques developed during experience in recent years are described and some changes in attitude toward earlier accepted procedures explained. Manner in which data are recorded is shown in tables.

"Ultrasonic Measurement of Tank Ship Corrosion Losses," D. J. Evans, Engineering Test Services, Inc. Corrosion, Nov 1959, 1061 M&M Bldg, Houston 2, Nov '59.

Rolling Friction

The rolling friction of a hard cylinder over a viscoelastic material is worked out in terms of the bulk properties of the material. It is found that the rolling friction has a maximum at a velocity corresponding to the peak of the relaxation time distribution. Both the load required to maintain the cylinder at constant depth of indentation and the coefficient of friction are dependent on the velocity of rolling. The shape of the rolling friction versus velocity curve is a first approximation to the distribution curve of relaxation times, indicating that rolling friction measurements can be used to determine the distribution experimentally.

"Rolling Friction of a Hard Cylinder Over a Viscoelastic Material," W. D. May, E. L. Morris and D. Atack. Pulp and Paper Research Institute of Canada. Journal of Applied Physics, Nov '59, 335 E 45th St, New York 17.

"Now I remember, I forgot to draw 'em up."

NEW BOOKS

High Speed Computing Methods and Applications

S H HOLLINGDALE. MacMillan Co, 60 Fifth Ave, New York 11. 5¾ x 8¾, 244 pp. $5.

Although this book is addressed to the general scientific reader (rather than the engineer, the businessman or the computer designer) the mechanical engineer will find much of interest here. The author is English and thus chooses items of English manufacture for his examples. Following the introductory chapters, for example, there is a description of the functional aspects of two English computers: EDSAC, a single address sequential computer, and DEUCE, a multiple address, nonsequential computer. The description centers around logical aspects and programming techniques —not the electronic details and circuitry. Final chapters discuss storage devices, logic design, and a number of practical applications: control of industrial processes, Monte Carlo methods, translation of languages, mathematical games, and operation of a computing center.

The Chemical Elements

HELEN MILLS DAVIS. Science Service Inc, 1719 N St, NW, Washington 6, D C. 4¼ x 7, 198 pp. $0.55 by mail for single copies.

All of the chemical elements are included in this second edition of the book first published in 1952. This paperback edition, edited by Glenn T. Seaborg and B. G. Harvey, contains the new discoveries that have occurred since Miss Davis' death in 1957. The story of the discovery of each element is told and its properties, sources, varieties, characteristic compounds and place in the periodic table discussed.

Industrial Design in the United States

Published by European Productivity Agency of the Organization for European Economic Co-operation. Order from OEEC Publications Office, 1346 Connecticut Ave, NW, Washington 6, D C. 6⅛ x 9½, 140 pp. $1.75.

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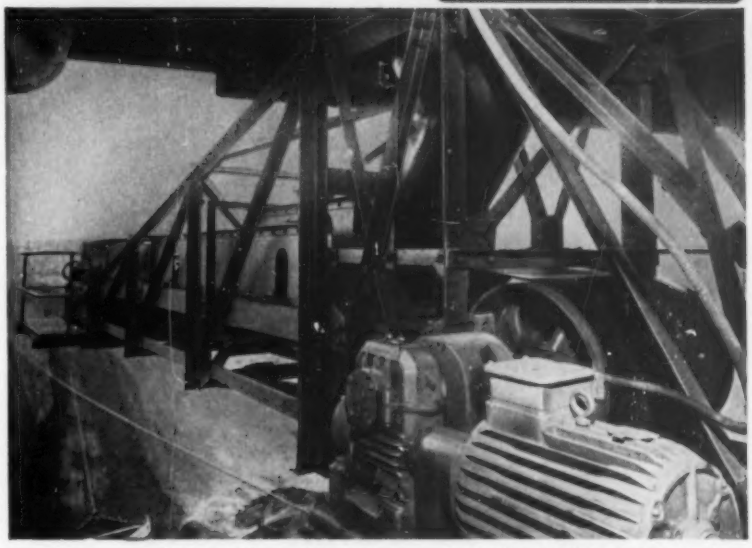

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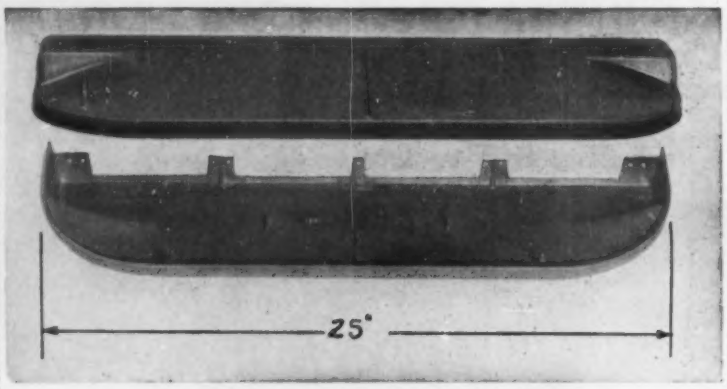

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other people's eyes is always a fascinating experience, and this book is no exception. It is a report based on the observations and recommendations of a European mission consisting largely of industrial management and engineering personnel that visited several cities, industrial design offices, schools and manufacturing organizations in Oct-Nov 1955. The main object of this venture was to describe and explain for European industrial management the processes and advantages of industrial design for a modern technological economy. This may well be one of the best–and certainly one of the most concise–studies of American industrial design and designers and their relations with American engineering and manufacturing.

Source Book of the New Plastics

HERBERT R SIMONDS. Reinhold Publishing Corp, 430 Park Ave, New York 22. 9 x 6, 354 pp. $10.

Here are the new plastics–their properties, production, price, applications and selection. Sixty plastics-producing companies contributed articles describing their own materials, including the seven new primary plastics of 1958. Described too, are the significant recent improvements in established plastics, and the 100 most important patents issued in the plastics field for 1958. An "Introduction to Polypropylene" explains Professor

(Continued on page 103)

". . . Sorry I'm so sentimental, but that's the first time you offered to come in on Saturday."

Natta's work and the earlier German development of stereospecific catalysts. The book gives complete information about polypropylene and polycarbonate and section on graft copolymers discusses the use of that technique in modifying plastics properties. Almost exclusively concerned with latest developments, the book also contains a survey of federal-sponsored research in plastics prepared by the Department of Commerce.

How to Increase Your Creative Output

Prepared by Deutsch & Shea Inc. Industrial Relations News, Book Dept, 230 W 41st St, New York 36. 8½ x 11, 22 pp. $1.50.

Designed to be supplied by management to members of engineering and research staffs, this booklet provides some guideposts for understanding and improving the creative faculties. A flowchart gives 12 steps in the creative process in the order they are supposed to occur most frequently. The do's and don'ts of defining a problem, getting underway, means of stimulating creative processes, are all discussed.

Design and the Production of Houses

BURNHAM KELLY and associates. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 17. 5¾ x 8¼, 401 pp. 410.

Authorities on architecture, materials, site planning, construction and other aspects of housing have prepared under the direction of Mr. Kelly (associate professor of city planning, MIT) a number of articles on the problems of providing shelter in quantities and of types suitable for

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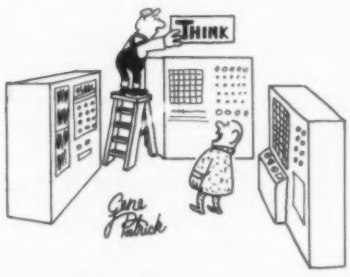

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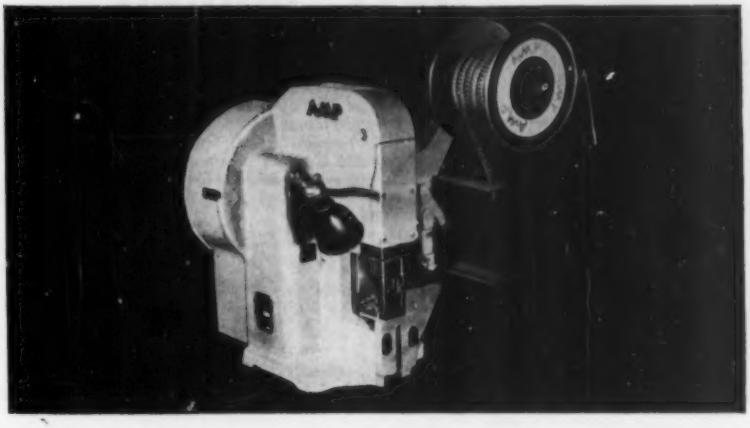

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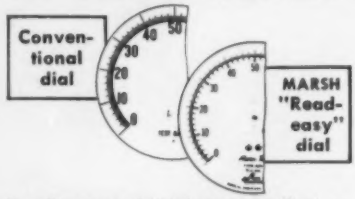

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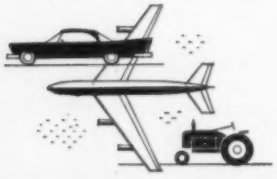

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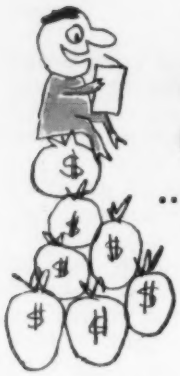

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our highly technological, urban era. This is probably one of the first books which puts the question of industrial production of houses in the sociological and market framework in which product engineers and designers will eventually have to approach it.

Other Books of Interest

Industrial Laminated Thermosetting Products.
LP 1-1959, National Electrical Manufacturers Assn, 155 E 44th St., New York 17. 8½ x 11, 72 pp, $2.75.

Transactions of the Fifth National Symposium on Vacuum Technology.
Edited by WILFRID G MATHESON, Pergamon Press, Inc., 122 E. 55th St., New York 22, NY. 8½ x 11½, 282 pp, $15.

Catalog of Technical Reports on Transistors—1949-58.
Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10, 6 pp, 10¢.

Wage Administration: Plans, Practices, and Principles.
CHARLES W BRENNAN. Richard D. Irwin, Inc., Homewood, Ill. 6 x 9, 440 pp, $8.10.

Metallizing Handbook.
H. S. Ingham and A. P. Shepard. Metallizing Engineering Co, Inc., Westbury, NY. 6 x 8½, 320 pp, $5.
Discusses processes, describes equipment and materials, and various kinds of coatings.

Human Engineering Bibliography: '56-'57.
PB 131507-S. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10, 369 pp, $5.

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St. Louis 8 . . . R. W. Bruley, 3615 Olive St., Continental Bldg., Jefferson 5-4867

San Francisco 4 . . . W. C. Woolston, 68 Post St., Douglas 2-4600

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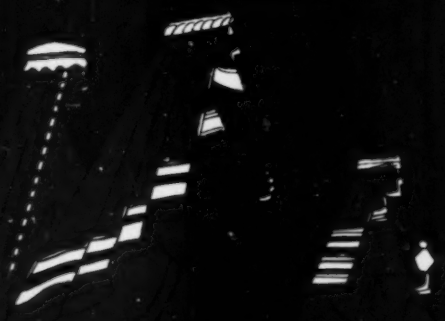

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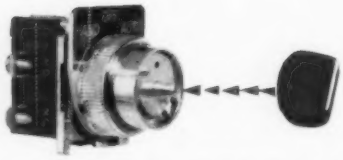

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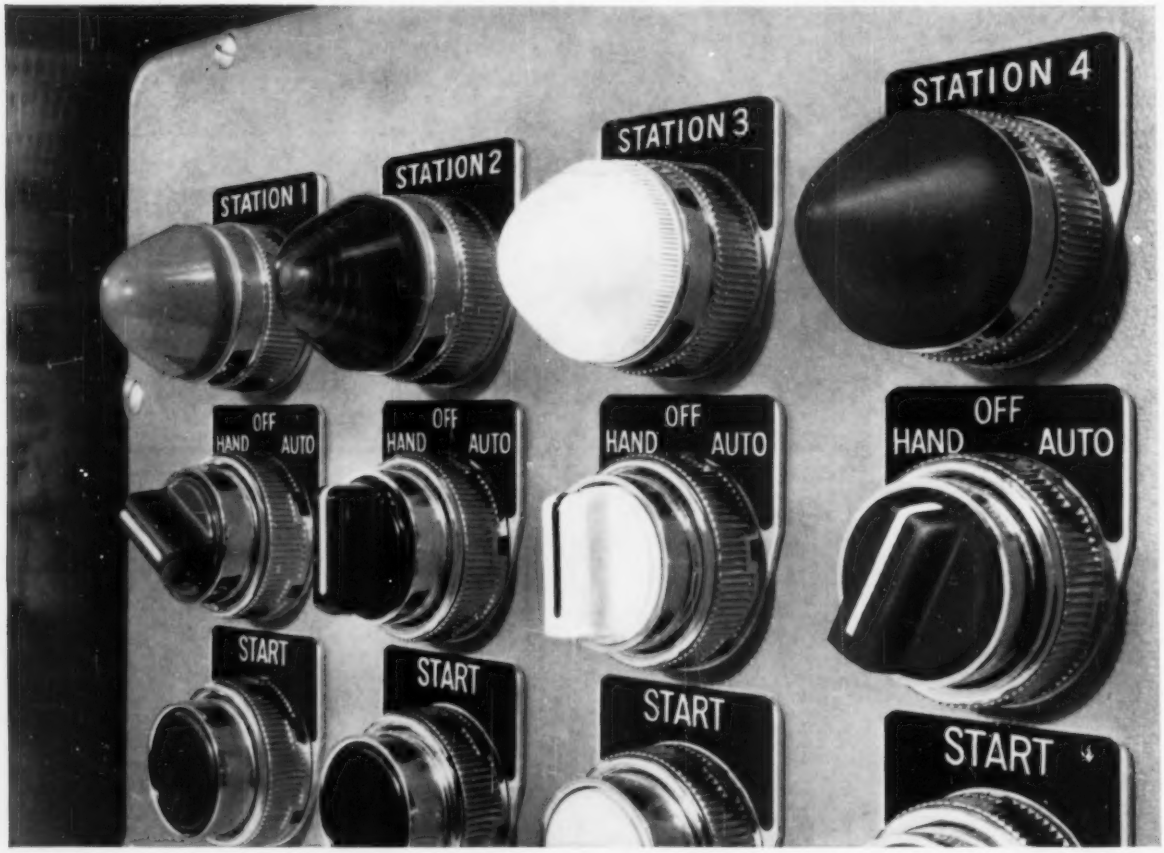

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